Sixty Seventh Annual Report

APRIL 1998 - MARCH 1999

INDIAN STATISTICAL INSTITUTE

203 Barrackpore Trunk Road, Calcutta - 700 035

PRESIDENT OF THE INSTITUTE, CHAIRMAN AND OTHER MEMBERS OF THE COUNCIL AS ON MARCH 31, 1999

President : Prof. M.G.K. Menon, FRS

1 Chairman : Dr. Bimal Jalan, Governor, Reserve Bank of India.

2 Director : Prof. S.B. Rao.

Representatives of Government of India

3. Dr. N.S.Shastri, Director General & CEO, National Sample Survey Organisation.

4 Shri Rakesh, Joint Secretary & Financial Adviser, Deptt. of Statistics, Ministry of Planning & Programme Implementation.

5 Dr. R.B Burman, Officer-in-Charge, Deptt. of Statistical Analysis & Computer Services, Reserve Bank

6 Dr. Laxman Prasad, Adviser, Deptt. of Science & Technology, Ministry of Science & Technology

Scientists not employed in the Institute
Representative of ICSSR

7. Dr. (Mrs.) R. Burman Chandra, Member Secretary, Indian Council of Social Science Research

Representatives of INSA

8 Prof. S.K. Malik, Chairman, CAS in Mathematics, Punjab University, Chandigarh.

9. Prof. R.K. Varma, Emeritus Professor, Physical Research Laboratory, Ahmedabad.

10 Prof. N Appaji Rao, Emeritus Scientist (CSIR), Deptt. of Biochemistry, Indian Institute of Science Bangalore.

11 Prof. V. Kannan, Deptt. of Mathematics & Statistics, University of Hyderabad, Hyderabad

Representative of the Planning Commission

12 Dr. S.P Pal, Adviser (Evaluation), Planning Commission, New Delhi

Representative of the University Grants Commission

13 Prof. G.K Shukla, Deptt. of Mathematics, Indian Institute of Technology, Kanpur.

Scientists Co-opted by the Council

14 Prof. M.G Nadkarni, University of Mumbai, Mumbai.

15 Dr. B.R Nag, Institute of Radio Physics and Electronics, Calcutta University, Calcutta

Elected representatives of members of the Institute not employed in the Institute

16 Prof. Deb Kumar Bose, Chairman, West Bengal Pollution Control Board Calcutta

17 Prof. Prabuddha Nath Roy, Pro-Vice Chancellor (Academic) Calcutta University, Calcutta

18 Shri B.K Pal, Former Head, SQC & OR Division, Indian Statistical Institute, Bangalore

Elected representatives of the employees of the Institute

19 Shri Ajay Ghosh, Representative of the Scientific workers

20 Shri Bhawani Shankar Chatterjee, Representative of the Non-Scientific workers

Officers of the Institute

21 Prof. Somesh Bagchi, Professor-in-Charge, Theoretical Statistics and Mathematics Division

22 Prof. K.S Vijayan, Professor-in-Charge, Applied Statistics Division

23 Prof. Atis Dasgupta, Professor-in-Charge, Social Sciences Division

24 Dr. Dilip Saha, Professor-in-Charge, Physics & Earth Sciences Division.

25. Prof. Dipak Kr. Bagchi, Professor-in-Charge, Biological Sciences Division.

26 Prof. B.P Sinha, Professor-in-Charge, Computer & Communication Sciences Division

27 Shri B. Majumder, Head, Statistical Quality Control and Operations Research Division

28 Prof. Dipankar Dasgupta, Head, Delhi Centre

29. Prof. Gadadhar Mishra, Head, Bangalore Centre.

30 Dr. P.S.S.N.V.P Rao, Dean of Studies

Non-Member Secretary

Shri Anup Majumdar, In-Charge (Administration & Finance).

INDIAN STATISTICAL INSTITUTE

Annual Report
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203 Barrackpore Trunk Road
Calcutta 700035
(www.isical.ac.in)

P. N. HAKSAR - AN OBITUARY

An intellectual giant, PARAMESHWAR NARAIN HAKSAR, truly epitomised the best values in life as a distinguished diplomat and upright and skilled administrator. P. N. Haksar belongs to the rare breed of men who are fortunate to have been able to combine a capacity to think with the opportunity to act. During an eventful tenure in a multi-faceted career that saw him serve the country as a diplomat, administrator and a sage advisor, Haksar discharged his duties with aplomb.

P. N. Haksar became associated with the Indian Statistical Institute (ISI) at a difficult turning point of its history in 1973, just after the founder of the Institute Professor P. C. Mahalanobis, the great visionary, passed away in 1972. Professor Mahalanobis made the Government sensitive to the importance of Statistical Science as a Key Technology and to its interfaces with various branches of knowledge and also to its applications. Haksar provided guidance over long twenty five years of his association in reinforcing its permanence and acceptability.

The first review committee of the ISI, to a certain extent, pointed out only the deficiencies in the then prevailing structure of the Institute but did not take into account, according to Haksar, the history, traditions and specific circumstances in which the Institute had grown. P. N. Haksar was familiar with these problems as he was then in the Prime Minister's Office and had much to do with trying to sort things out. Under the Chairmanship of P.N. Haksar, an Institutional framework was created in 1976 for proper functioning of the Institute with democratic norms at lower levels as well. Haksar believed that in actual practice, the orderliness in a system's functioning is largely due to the linkages established at the ground level. "Haksar beats a computer in analysis any time", many in ISI and Government said in awe of the mind behind the man who was an action-oriented thinker with a balanced approach to problems. Following the great example of the founder of the Institute, Haksar gave his heart and soul to the furtherance of the objectives of the Institute as laid down in the Memorandum of Association (MoA) and guided the Institute with his exemplary intellectual, academic and administrative abilities.

From 1973 onwards, the ISI was foremost on his list of priorities. The Delhi centre of ISI was created under his Chairmanship in 1974. He fought relentlessly to maintain the autonomy of ISI to further its academic excellence. He exhibited exemplary courage and fortitude by spending several hours, when his wife was lying in hospital gasping for life, to deal with matters pending with the government regarding ISI, including writing a letter from the hospital waiting room to the government. He never allowed the Institute to be swayed by Government control and always swore by the ISI ACT of Parliament of 1959 that declared the Institute as an "Institution of National Importance."

Professor Mahalanobis is without doubt the Messiah of the Statistical Quality Movement in India. Haksar lent his whole-hearted support to its substantial growth in India through ISI which finally made the Government of India realise its importance. Under his insistence, the Government constituted the Quality Council of India in 1998 and rightly made the ISI a permanent member.

Haksar was a constant source of guidance and inspiration to the workers of the Institute, including the ISI Workers' Organisation (ISIWO). In the recent past, he made special efforts to solve several long standing problems of the Institute which include: amendment in 1995 of the Section 4 of the Indian Statistical Institute Act of Parliament of 1959 empowering the Institute to award degrees and diplomas not only in Statisitics but also in Mathematics, Quantitative Economics, Computer Science and such other subjects related to Statistics as may be determined by the Institute from time to time; approval of a number of changes in the MoA of the Institute in 1996 which included creation of a new Division of Computer and Communication Sciences and also recognition of the Bangalore Centre formally as a Centre in MoA.

His guidance and influence, and the great respect he commanded at the highest levels in Government, combined with the excellent research, project work, teaching and consultancy done by the scientists, helped the Institute in its continuance as a Centre of Excellence in the World of Statistics and Learning. His love and affection for the Institute and its workers will always remain etched in our memory. May his soul rest in peace.

P.N. Haksar

04.09.1913 - 27.11.1998

INDIAN STATISTICAL INSTITUTE
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BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early twenties through the pioneering initiative and efforts of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological Survey of India) and subsequent interactions with him led to the first scientific paper by Mahalanobis on the statistical analysis of stature of Anglo-Indian males of Calcutta. This was followed by further research in anthropometry, in meteorology and in problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists was picked up by him in the Department of Physics, Presidency College, Calcutta, where he was a professor. This group formed the nucleus of a laboratory which later came to be known as the Statistical Laboratory.

In the early thirties, realising the necessity for a concerted effort for the advancement of theoretical and applied statistics in India, Professor Mahalanobis together with Professors P N. Banerjee and N.R. Sen, both of Calcutta University, convened a meeting on 17 December, 1931, to consider various steps to be undertaken for the establishment of an association for the advancement of statistics in the country. It was unanimously resolved that the Indian Statistical Institute be established with Sir K.N. Mookerjee as President and Professor P.C. Mahalanobis as (Honorary) Secretary. The Indian Statistical Institute (ISI) was registered as a non-Government and non-profit distributing learned society on April 28, 1932, under the Societies' Registration Act No. XXI of 1860. The total expenditure in the first year was a meagre Rs. 238.00 and the number of workers was only two or three. From such a modest beginning, the Institute grew, under the remarkable leadership of Professor Mahalanobis, into an all-India organisation which now has around 1600 workers, including about 500 scientific workers. The Institute has its headquarters in Calcutta and two other Centres at Delhi and Bangalore and a branch at Giridih. In addition, it has a network of service units of Statistical Quality Control and Operations Research Division at Baroda, Mumbai, Pune, Coimbatore, Chennai, Hyderabad, Calcutta, Delhi and Bangalore.

From the very beginning, Professor Mahalanobis and his associates, which included Professors S.S. Bose, R.C. Bose, S.N. Roy, K.R. Nair, K. Kishen and H.C. Sinha worked with enthusiasm for the development of statistical theory and methods, and in promoting research and practical applications in different areas of natural and social sciences. *Sankhyā*, the Indian Journal of Statistics, was started in 1933 with P.C. Mahalanobis as its Editor, and received instant international recognition which continues till today. Pioneering research activities were carried out in many areas of statistical theory, especially in the core areas of multivariate analysis, sample surveys and design of experiments. Such activities were strengthened and new directions were opened up by Professor C.R. Rao and many others who joined the Institute in the forties, and the tradition continues. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale sample surveys. This led to a large number of research publications and to the introduction of training activities offering short term courses in statistics for officers in government departments and scientific institutions. The scientists of ISI, led by Professor Mahalanobis, helped in introducing the first post-graduate degree course in statistics in India at the Calcutta University in 1941, and in securing a separate section for Statistics in the Indian Science Congress.

Activities of the Institute gained further momentum from 1938. Professor Mahalanobis started sample surveys to estimate the area under jute crop in Bengal in 1937 as an exploratory work, which later grew to a full-scale survey of the entire province in 1941. At the request of the Government of Bengal in 1944, a survey of economic and social conditions in Bengal was undertaken to assess the impact of the severe famine which had occurred in 1942-43. This survey yielded information of much social significance. These projects led to a debate on the use of sample surveys, which were ultimately accepted as the basis for official estimates of crop yield in West Bengal in 1948, and later in other states of India. Gradually, sample surveys of agricultural crops and other socio-economic surveys became some of the most important activities of the Institute and earned the Institute and Professor Mahalanobis international reputation. After independence, Professor Mahalanobis was appointed Honorary Statistical Adviser to the Cabinet, Government of India, and in 1950, through his initiative, the National Sample Survey (NSS) was started for conducting socio-economic surveys of all-India coverage on a continuing basis. This was the first ever attempt in India to have a data base for various developmental

by inviting other experts like W.E. Deming for the same purpose. SQC promotional work was gradually spread all over the industrial centres in India under a comprehensive programme covering education and training, applied research and consultancy services.

Research in economics was greatly stimulated when in 1954 Prime Minister Jawaharlal Nehru entrusted the preparation of the draft Second Five-Year Plan of the country to Professor Mahalanobis and the Institute. The "Draft" submitted by Professor Mahalanobis and the planning models formulated by him in that connection have since been regarded as major contributions to economic planning in India. Since then many economists of the Institute have worked in different centres of the Institute on various aspects of national planning and until 1970, were directly helping the Planning Commission in the preparation of the long term perspective plans for the country. Research in other disciplines of Social Sciences was also started in the Institute in the late fifties. Professor Mahalanobis' participation in 1946 in the annual scientific conferences of the Milbank Foundation led to the initiation of systematic studies in India on the growth of population. Earlier, the well known Y-sample estimates for 1941 Census population were also derived by the ISI. Theoretical and empirical research in sociology using statistical techniques was started in the Institute for the first time in south-east Asia. Similarly, the development and introduction of psychometric tests for selection processes in different organisations was first made by the ISI in India besides carrying out basic research in Psychometry. The studies of the phonetic structure of some major Indian languages have been made on a continuing basis in the Institute under the guidance and collaboration of the famous linguist Djordje Kostic.

The Institute, since its inception recognised the need for development and use of accurate and fast computing equipment for the processing and analysis of data. Professor Mahalanobis strongly believed that to be a good theoretical statistician one must also compute and must therefore have the best computing aids. The Institute has lived up to this tradition from the very beginning. In 1953, a small analog computer was designed and built in the Institute. In 1956, the Institute acquired a HEC-2M machine from the U.K, which was the first digital computer in India. In 1958, a digital computer URAL was received as a gift from U.S.S.R. Since 1956 till mid sixties, the Institute had been serving as a de facto national computer centre for the country. In early sixties, the Institute, in collaboration with the Jadavpur University, undertook the design, development and fabrication of a fully transistorised digital computer, called ISIJU-1 which was commissioned in 1966 by Shri M. C. Chagla, the then Minister of Education, Government of India.

Quantitative analysis in Physical and Earth Sciences was one of the novel ideas of Professor Mahalanobis pursued in the true spirit of the Institute. In addition to evolving some interesting techniques and obtaining some very interesting results from the analysis of directional geological data, the Institute also made a significant contribution by discovering the bones of a 16m (+) long sauropod dinosaur named, *Barapasaurus Tagoreii*, from the lower Jurassic Kota rocks near Sironcha, Gadchiroli district, Maharashtra, in the sixties. The discovery has helped in understanding the interesting problem about the origin and evolution of sauropod dinosaurs. It, in fact, represents the only intermediate form between the prosauropods and the sauropods, and is called a "missing link" in the evolution of the sauropod dinosaur.

The Institute expanded its research, teaching, training and project activities and earned national and international recognition over time. The substantial contributions of the Institute to theoretical and applied statistical work have culminated in the recognition of the Institute as an Institute of national importance by the Government of India through the Indian Statistical Institute Act, 1959. By the act the Institute was empowered to award degrees and diplomas. None other than Pandit Jawaharlal Nehru, the then Prime Minister of India, piloted the bill in the Parliament. With this recognition, the already existing teaching and training programmes were consolidated and expanded and courses for the degrees of Bachelor of Statistics [B.Stat. (Honours)] and Master of Statistics (M.Stat.) were started from June 1960. The Institute was also empowered to award Ph.D./D.Sc. degrees from the same time. Later on, courses leading to Master of Technology degrees were started in Computer Science and in Quality, Reliability and Operations Research which also received formal recognition from the All India Council for Technical Education (AICTE). Subsequently, a Master of Science programme in Quantitative Economics was also introduced. In recognition of the excellent research work done by the scientists of the Institute in several areas related to statistics, the section 4 of the Indian Statistical Institute Act of 1959 was amended by the Parliament in September 1995 to empower the Institute to award Degrees/Diplomas not only in statistics but also in mathematics, quantitative economics, computer science and such other subjects related to statistics as may be determined by the Institute from time to time.

The role and importance of ISI in conducting and promoting teaching of statistics has been appreciated by international bodies as well. In 1950, the International Statistical Institute had initiated the International Statistical Education Centre (ISEC), Calcutta, jointly with ISI, to impart training in Theoretical and Applied Statistics to participants selected from developing countries. The centre is run by ISI jointly under the auspices of UNESCO, International Statistical Institute and the Government of India.

Recognition of the Institute by the Act of Parliament provided greater encouragement to research activities not only in statistics and mathematics but also in various branches of the natural and social sciences, without whose live contact, it was believed, the methodology of statistics could not grow to its current level. It is also due to this fact that "Unity in Diversity" is adopted as the motto of the Institute. In view of these, the Memorandum of Association of ISI was updated first in 1976 and subsequently in 1995. The objectives of the Institute as laid down in the Memorandum of Association are :

i) to promote the study and dissemination of knowledge of statistics, to develop statistical theory and methods, and their use in research and practical applications generally, with special reference to problems of planning for national development and social welfare;

ii) to undertake research in various fields of natural and social sciences with a view to the mutual development of statistics and these sciences; and

iii) to provide for, and undertake, the collection of information, investigations, projects, and operational research for purposes of planning and the improvement of efficiency of management and production.

iv) to undertake any other ancillary activities in fulfilment of the objectives i), ii) and iii) above.

The units of academic, scientific, project and administrative service activities of the Institute were regrouped into eleven divisions under the new Memorandum of Association (MOA) of the Institute effective from 1996.

From the early days, the Institute has been in touch with many internationally famous scientists in different disciplines from the world over. Some of these scientists have worked in the Institute for several months or even longer. Sir Ronald A. Fisher, a pioneer of modern statistics, was a regular visitor to the Institute and lent it considerable support. Professor J.B.S. Haldane, a geneticist of international repute, was a member of the faculty for several years beginning from 1957. At the inspiration of these stalwarts and other renowned scientists, the Institute began to expand and/or undertake research activities in several areas of natural and social sciences with the hope that collaboration under the same roof would foster the mutual development of statistics and other disciplines. In fact, the Institute stood up to Sir Ronald Fisher who called Statistics a "Key Technology" of the century, in view of its intimate relevance to all scientific endeavours which involve experimentation, measurement and inference from sample to aggregate.

Coming to more recent times, the Institute has continued to pursue its goal of attainment of excellence in the various fields of science. Fundamental research in statistics with its roots in applications has been the bottom line ever since the inception of the Institute. The contributions from the Institute in multivariate analysis, design and analysis of experiments, sample surveys, statistical methods of data analysis and statistical inference have found their places in text books and monographs, and the tradition continues. In addition, probability theory and stochastic processes have also been major areas of research in the Institute. The theoretical mathematicians of the Institute, in addition to collaborating with the statisticians, are also making fundamental contributions in several fields - Topology, Functional analysis, Harmonic analysis, Algebra, Combinatorics, Quantum Mechanics, Game Theory, to name some. The current trend of research in statistics not only carries forward the traditions set up in the Institute, but is also setting new directions, both in theory and applications, in different disciplines.

The Institute has been maintaining its tradition of high quality research and development in the field of computer science. In 1979, a microprogrammed signal processing system using Fast Fourier Transform (FFT) was designed and developed. Keeping pace with the global advances in computer technology, the activities of the Institute in the field of computer science gathered a tremendous momentum in the late seventies, resulting in diversification of research in different areas including Algorithms and Complexity, Parallel and Distributed Processing, Fault-Tolerant Computing, VLSI, Computational Geometry, Fuzzy Sets and Systems, Cybernetics,

Pattern Recognition, Neural Nets, Artificial Intelligence, Image Processing, Computer Vision, etc. In recognition of its contributions in the field of computer science, the Government of India established, in collaboration with the United Nations Development Programme (UNDP), one of the five national Nodal Centres for Knowledge Based Computing Systems (NCKBCS) at ISI in the year 1988. The Institute also has the infrastructure for providing the most modern computational environment with facilities for e-mail, internet connection, etc.

The different disciplines under the Social Sciences also continued to develop and flourish over time by carrying out basic research as well as inter and multi-disciplinary programmes. In economics, the Institute has come to be known as a specialized centre for its significant contributions in different branches of theory and also for studies on such areas as Demand Analysis, Poverty and Levels of Living, Measurement of Inequalities, Production and Prices, National Income and allied topics, Development and Planning etc. In Demography, Sociology, Psychometry and Linguistics also the Institute maintained its distinctive feature for the focus and emphasis on quantitative aspects. Mention may be made, in this context, about the pioneering theory for teaching and training for the hearing impaired children, developed by Prof. Kostic. Based on this theory the Electronics Unit of the Institute, in collaboration with the Linguistic Research Unit and the Government of Tripura, designed, developed and fabricated a set of instruments for the hard-of-hearing children of the Institute of Speech Rehabilitation, Government of Tripura, Agartala. This has come to be regarded as having a significant impact on social welfare.

Plant and human biology have been the major areas of research in biological sciences. Both basic and applied research are conducted, with emphasis on quantification, statistical design and analysis, and modelling. In the area of plant biology, research has included quantification of natural variability and modelling, animal behaviour, effect of interaction of rice varieties on yield, use of protein extracted from leaves to supplement human food, mathematical modelling of ecological and embryological phenomena, etc. In the area of human biology, researches have included anthropometric, genetic and biochemical studies on population affinities, micro-evolution, studies on utilising data on anthropometric variability in designing car seats, human adaptation to differing environments, human ecology and growth and genetic epidemiology.

With a view to developing innovative methodologies for collection and analysis of quality survey data, interacting and collaborating with organisations like NSSO, CSO, DoS, Planning Commission, RBI, etc., promoting the growth of inter-disciplinary research in statistics and data analysis in the Institute, and disseminating the methodologies (old and new) to the scientific, academic and research organisations, a Survey Research and Data Analysis Centre (SURDAC) has been established at the Institute in February 1997. Such a centre would benefit the planning processes and national development. In 1995, the Plan and Policy Research Unit (PPRU) was established under the Planning Unit at Delhi Centre which has already undertaken several projects of national and international importance.

Over the years, the SQC & OR Division has grown to the size of having ten operating units all over the country and have uniquely served for promotion, education and training and technical guidance in Total Quality Management Methodology, Quality Assurance Systems for the benefit of the manufacturing and service industry over the decades. It has thus, as was intended, played a leading role in dissemination of new concepts, methods and techniques in the areas of Quality and Productivity.

The Central Library of the Institute is located at Calcutta with a network extending to other locations of the Institute. Over the years, the library of the Institute has attained the distinction of being one of the richest libraries in the country, particularly in the fields of statistics and related disciplines. The library has developed a well-equipped Reprography and Photography Unit. The library's gift collections include the personal libraries of Professor P.C. Mahalanobis and Professor Walter A Shewhart. The library has been recognised as the Depository Library for World Bank publications. A separate collection of books and journals in Mathematics, Statistics etc., known as Eastern Regional Centre of National Board of Higher Mathematics(NBHM) has been developed out of the grants from the (NBHM) . Computerization of library facilities has been taken up which will certainly enhance the facilities for the users. Much more is on the anvil in this direction.

The Professor P. C. Mahalanobis Memorial Museum & Archives, which was inaugurated on June 29, 1993 by Shri P. V. Narasimha Rao, the then Prime Minister of India, has been established in *Amrapali* on the Institute campus in Calcutta.

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The Documentation Research and Training Centre (DRTC) established at Bangalore in 1962 by the late Professor S.R. Ranganathan, a doyen in the field of library and information science, is engaged in research, teaching and training in documentation and information science. The Institute awards post-graduate diplomas in documentation sciences.

An index of the contributions of the Institute is the publication of many books and monographs, in addition to a large number of scientific papers in national and international journals, receipt of national and international recognitions of very high order by the scientists of the Institute in terms of awards, titles, and fellowships, and holding of prestigious positions in various scientific organisations of higher learning as well as in governmental organisations both in India and abroad. With a dynamic group pursuing and guiding research work in some of the most modern topics in statistics, mathematics, computer science, economics and in various fields of natural and social sciences, there exists a close interaction among the scientists from all over the world.

DIRECTOR'S REPORT

During the year 1998-99 training in core areas of Statistics, Mathematics, Economics, Computer Sciences and other related areas was in full gear. The scientific and technical workers kept a busy schedule with research activities, project works, case studies and professional activities both in Theoretical and Applied Statistics, Mathematics, Economics, Computer Sciences as well as in Social, Natural Sciences and in Interdisciplinary areas. As an interaction between Statistics and Computer Sciences a novel approach to statistical smoothing based on some fundamental ideas from the scale space theory in computer vision have been developed in the Stat-Math Unit at Calcutta. On non-parametric estimation of curves and surfaces, a statistician frequently encounters the question "which observed futures are 'really there' (that is, Statistically significant ?)" as opposed to being spurious artifacts of sampling variations or noise in the data. A graphical device, which produces colored display of Statistical significance of different features that are describable using derivatives of a smooth curve or surface at different scale of smoothing, has been developed.

The Plan and Policy Research Unit (PPRU) at the Planning Unit at Delhi has undertaken several projects of national and international importance which include : Gender Bias, Group behaviour of firms; Impact of agricultural innovation on consumption; Promoting Econometric Cooperation with ASEAN; Promoting Financial and Technological Cooperation with ASEAN. The Survey Research and Data Analysis Centre (SURDAC) has taken up several interdisciplinary research projects covering areas such as : Statistical Modelling and Analysis of Psychological, Physiological and Ecological repeated measurements data; Study of Level of living and employment patterns and inter relationships based on household level NSS data; Statistical analysis of personal, social and back ground variables on academic achievement of primary school students; Survey methodology for studies on mobile population; Human Uterine Cervix Cancer data base : Network Approach; Numerical Simulation of Fluvial Processes. It is being planned to undertake several projects undr SURDAC in collaburation with the NSSO, CSO, and DOS of the Government which may include : Developing methodology to estimate the contribution of small scale industries to the GDP; Suggesting appropriate methodology, suitable in Indian conditions for calculation of the Human Development Index, Gender Development Index, Gender empowerment measurement; Identifying reasons for the dropouts and estimating the educational standards reached in the country; Developing methodology to obtain the maternal mortality rates and birth rate, infant mortality rate at Sub-State level. These signify the interface of statistics with planning and policy processes and the Governmental/ Institutional efforts for welfare of the Society.

The use of Statistical Quality Control and Reliability techniques, in controlling loss and cost and for improving and augmenting productivity in industries, has generated great impetus to the Quality Movement in the Country. Professor P.C. Mahalanobis was a Messiah of this Quality movement in India which was initiated at this Institute in 1948. The Institute with its expertise in the Quality Movement since the last 50 years is providing training and consultancy through its SQC & OR Units spread over the country in all areas of quality management and quality systems related to ISO-9000 Certification. The Institute celebrated the 50 years of the SQC & OR movement in the country by conducting a National Conference on "Business Competitiveness and Growth Through Quantitative Methods" during 06-08 August,1998 at Chennai, to review the development and applications of SQC & OR in these 50 years, to have a look at the current scenario in the development of SQC & OR in Indian organisations; and to discuss the further possibility of an Interface between Industry and Academia and chart-out the Institute's future directions in this regard . I would like to mention here that due to the special efforts made by late P. N. Haksar, who was the Chairman of the Institute for 25 years from 01 November 1973 till his death on 27 November 1998 and rendered valuable service for the continuance of the Institute as a Centre of Excellence in the world of Statistics, Mathematics, Economics, Computer Sciences and related areas; the Government of India constituted recently the "Quality Council of India (QCI)" and the Institute has been made a permanent member of the QCI. During the year 1998-99, services of the SQC & OR Division for designing and implementation of ISI-9000 quality systems were rendered to 120 organisations, The crash programme for "Training of Trainees" undertaken as the "Quality Mission Project" during the 8th Five Year Plan is continuing in the 9th Five Year Plan period with some change in focus, on training programmes and systems implementation to industries such as Leather; Food Processing, Gems and Jewellery, Service Sector, Small Scale Industries, Environment and Quality System Implementation for financial services, including Banks and Health Management etc. Efforts for export of our consultancy service have been initiated.

In research in Computer Science, a new technique for the High Performance Routing of multichip modules has been proposed by the ACM Unit. The new algorithm has been tested on standard bench marks, and it has been observed that it out performs the results of the existing algorithms with respect to via Count, wire length, cross talk and delay in signal propagation. The first Bangla Script Optical Character Recognition (OCR) system built by the Institute scientists in CVPR Unit can now automatically read pages of Bangla books printed by reputed publishing house. The development of Devnagari (Hindi) OCR System is also nearly completed. The two systems are now being integrated to make a bi-script, bi-lingual OCR that will cover the most popular scripts of the sub-continent. The MIU undertook extensive study on chaotic dynamics in artificial neural models to demonstrate their effectiveness for brain modelling. A fast and automatic Image Compression Technique for multimedia applications has been developed using Markov operators and fractal Mathematics. The ECSU made significant progress on Remote Sensing and Data Analysis in Atmospheric Science and wave propagation.

Important contributions have been made by colleagues in Economic theory, International trade econometrics, health sector reforms, dynamical systems, finance, poverty and human development indices and agricultural economics.

The Institute also undertook several externally funded projects of National and International importance from different government and non-government organisations including International Organisations.

In the project "Genomic Diversity in Indian Populations : Investigation through Bio-Technological Tools in Eastern Indian Populations" (Jointly with DBT, Gol, IICB, SINP) the AHGU made considerable progress. Through the analysis of autosomal, y-chomosomal and mitochondrial DNA markers of various ethnic groups of India, the investigators have provided evidence of prehistoric demographic human expansions in India, migrations of humans from India to South-East Asia etc. The study has already attracted wide attention and received appreciation during the recent Indian Science Congress. The Planning unit at Delhi completed the project on "Counting the Poor" of the DOS, GOI. The most important conclusion of this study based on the NSSO data, is that, "there has been a decline in the incidence of poverty and in the condition of the poor, in 1993-94 over that in 1987-88 at the all India level irrespective of the poverty line used. There is a perceptible decline in the Head Count Ratio (HCR) for both rural and urban sector when considered separately".

The other externally funded projects include : Environmental Management Capacity Building Technical Assistance Project - Environmental Economics Component (Ministry of Environment and Forests & IDA, World Bank); Health Sector Reforms : An Evaluation of Impact and Patterns of Utilisation Among Vulnerable Groups in the Three Indian States (AP, TN, WB) (Ministry of Health and Human Welfare and European Commission); Software Development for Cryptanalysis (DRDO); E_a-semigroups and Dilation Theory (INSA); New Techniques for Fast Image Compression based on Human Vision Systems and Geometric Data Structures (INTEL Corporation, USA) : Strengthening Local Government : The case of Madhya Pradesh (PWI, Govt. of Madhya Pradesh); Risk Analysis of a Coal Supply Agreement (Coal India Ltd.); Compilation and Optimisation for Re-configurable Coprocessors (IRISA, France); Bilingual (Bangla & Devnagari) OCR System Development (DST); Tracer Study of ITI Graduates (Ministry of Labour, GOI); Indepth Studies on the Levels of Development of Scheduled Casts and Scheduled Tribes (Ministry of Welfare, GOI); Development of a Spell Checker and Morphological Processor in an Indian Language with Speech Support for the Blind (DoE, Gol); Development of a Real-Time Intelligent Decision Output System for Range Safety (DRDO); A Neuro-Fuzzy Image Recognition System : Methodology Development for Forensic Applications (CSIR); A Study of Mathematical Techniques in Water Wave Problems (CSIR); Development of Statistical Technique as an Aid to Geological Mapping (CSIR); Cancer Management in Soft Computing Paradigm (CSIR); Studies of the PBL Dynamics using Sodar and Tower Data and to predict a Scalar Transport Model for the Monsoon Periods (DST); Large Amplitude Ion & Electron Acoustic Waves in Relativistic Plasma (DST); A Neuro-Fuzzy Image Based Framework for Diagnosis and Therapeutic Planning using Multimodality Medical Imaging (DST); Development of Methodologies for Self Organising Fuzzy Logic Controllers with special emphasis on Neuro-Fuzzy Techniques, Genetic Algorithms and Stability Analysis (DST); Savings and Investment Intermediation in the Indian Economy - A structuralVvector Auto Regression Model (RBI); Evaluation of Rainfed Farming Project (ODA, UK); Change in Livelihood Trajectories (UEA, UK); Sustainable Livelihood Studies under Environmental Stress in Eastern Plateau of India (UEA, UK), Rice Based Cropping System Studies in Rainfed Regions of Eastern Indian Plateau (IRRI); Development of CAD Tools for Identification of (i) Logical Equivalence of Library Elements & (ii) False Path in Switch Level Network (Motorola & IIT, Kharagpur); Molecular Epistasis and the Human Globin Gene Clusters with special reference to Haemoglobinopathies in Eastern India (DBT, Gol); Genetics of Quantity Traits of Commercial Importance of the

Silkworm (CSB); Survey of Possibilities & Problems of Small Industries in Birbhum district (Govt. W.B.); Total Literacy Campaign (TLC) project in Calcutta Municipal Corporation area (CMC); TLC project in Purulia district of West Bengal (Govt. of W.B.), Evaluation of Continuing Education in the district of South 24-Parganas (Govt. of W.B.); Algorithm Development for Natural Language Processing (IILCA, Tokyo University of Asian Studies, Japan); Algorithm Development for Pattern Recognition & Image Processing of Biomedical Pictures (GDF, Munich, Germany); Mid-Term Review of Family Welfare Project IPP-VIII, Calcutta (CMDA); Application of Fractal and Multifractal Techniques in the Processing of Atmospheric Data Image (DST); Development of Image Processing Technique for Improved Wind Estimates using INSAT Cloud and Water Vapour Imageries (ISRO); Structural and Pathological Constraints on the Evolution of Granulite Green Stone Contact around Paikmal, Orissa (DST); Interaction of Water Waves and Structures (CSIR); Chemical Communication of the Big Cats, Tiger, Leopard and Cheetah (CSIR); Development of Software for creating Bioliographical Records based on OCR Technology (NISSAT, DSIR).

In appreciation and recognition of the high standards of research and scientific excellence maintained by the researchers and scientists of the Institute, several faculty and scientists of the Institute received laurels in the form of awards and fellowships from Institutes/organisations of National and International repute.

Professor J.K. Ghosh, Jawaharlal Nehru Professor and Professor K.R. Parthasarathy; INSA C.V. Raman Professor in the Institute and Distinguished Scientist, Professor B.L.S. Prakasa Rao; the recently appointed distinguished Scientists Professor B.V. Rao, Professor K.B. Sinha, Professor T. Parthasarathy, Professor S.K. Pal are with us by providing academic leadership at the Institute. Several other colleagues and young faculty have received young scientists award and fellowship, membership, associateship awards from scientific boards such as INSA, Indian Academy of Science etc.

It has been a practice of the Institute to share its expertise and its facilities with colleagues and scientists, researchers and teachers from other Institutes, universities, colleges and research and scientific organisations. Following this view, various national and international conferences, summer/winter schools, symposia, seminars and workshops were held during the year to disseminate results obtained as well as to strengthen the research, project works, case studies and consultancy and professional work of the Institute with fresh ideas and methods. Several international conferences/workshops have been held during 1998-99 which emphasis the basic role of statistics as a key technology.

The Stat-Math Division organised an Interdisciplinary winter schools on "Statistical Methods in Medicine, Health and Environmental Issues" and Transformation Groups", workshops on "Variance Components Estimation and Optimal Designs" at Calcutta; and an International workshop on "Recent Advances in Operator Theory and Operator Algebra" at Bangalore Centre, Regional and National Mathematical Olympiad at Calcutta and the Nurture programme of the NBHM for Indian National Mathematical Olympiad Students at Bangalore Centre. The Applied Statistics Division conducted a summer school on "Small Area Estimation" and the UGC Refresher Course (PG level) at the all India level for researchers and post graduate students. The Social Sciences Division organised a mini conference on "Application of Recent Advances in Quantitative Techniques to Indian Econmic Studies' by the Economic Analysis Unit at Bangalore Centre. "The Indian and South Asia Econometric Society Conference" at Delhi Centre, a national conference on "Aims of Computational Linguistics" and a seminar on "[M]other Tongue Syndrome : The Case For Or Against the Introduction of English in the Primary Level of Education in West Bengal" by LRU at Calcutta.

The Computer and Communication Sciences Division organised two-month International workshops on "High Performance Computing" by ACMU and "Image and Shape Analysis" jointly by CCSD, Stat-Math. and Applied Statistics Divisions at Calcutta. The latter was the first such workshop under the twinning arrangement between ISI and the University of Leeds, UK. These two workshops were attended by leaders in these fields who emphasised on the importance of statistics in the era of computing and on the interface of statistics and computer science. The Institute also co-sponsored the National Symposium on "Acoustic : Speech, Music and Noise Pollution" with Sangeet Research Academy and the Acoustic Society of India. The SQC & OR Division held a National Conference celebrating 50 years of SQC & OR movement in India on "Business Competitiveness and Growth Through Quantitative Methods" at Chennai. The SQC & OR Division held a winter school on "Design and Analysis of Experiments" at Hyderabad branch. The Library, Documentation and Information Sciences

Analysis of Experiments" at Hyderabad branch. The Library, Documentation and Information Sciences Division organised a workshop on "Information Management" and a Short Course on "Computer Applications" at Bangalore Centre.

The Institute invites a distinguished statistician every alternate year to deliver the prestigious Mahalanobis Memorial Lectures at Calcutta and at the centres at Delhi and Bangalore. These lectures were delivered this year by Professor C.F.J Wu, H.C. Carver Professor of Statistics and Professor, Industrial and Operations Engineering, The University of Michigan, Ann Arbor, USA, during 26 February 1999 to 08 March 1999. The main theme of these thought provoking Interdisciplinary talks was "Statistics, Data Science, Experimental Designs". Professor Wu delivered a series of lectures on (i) Statistics - Data Science, (ii) "A System of Experimental Design" (view on experimental designs, their classifications, some very novel idea) (iii) "Industrial Experimental Design : Box, Taguchi and Beyond" (applied engineering / science oriented old and new strategies), (iv) "Exploration of Complex Aliasing in Non-Regular Designs" (topical and futuristic looking).

Regarding the teaching and training activities of the Institute, during the year 8164 candidates applied for admission to various courses offered by the Institute including B.Stat.(Hons.), M.Stat.(M & S Streams), Master of Science in Quantitative Economics, M.Tech (Computer Science), M. Tech. (Quality, Reliability and Operations Research) etc. A total of 6260 candidates finally appeared for the admission tests conducted at different centres all over the country. A total of 527 candidates qualified for interview for final selection. Based on the academic record and performance in the written tests and interviews, a total of 220 candidates were offered admission to various courses leading to the degrees and diplomas during the academic session under review. It may be mentioned here that encouraged by the recent amendment of the ISI Act of 1959, by the Parliament of India in 1995, which empowered the Institute to award degrees and diplomas not only in statistics but also in mathematics, quantitative economics, computer sciences and other subjects related to statistics, a two year Master Degree Course in Quantitative Economics was introduced by the Institute in 1996 to meet some of the needs of the country for development of human resources and research, and the first batch of students who had completed this course in July 1998 were awarded their degrees (M.S. in Quantitative Economics) in the 33rd convocation held on 02 February 1999. The Convocation address was delivered by Sir Walter F. Bodmer, F.R.S. The B. Math (Hons.) course is being planned to be introduced in the near future to train students rigorously to enable them to study M. Math courses and to acquire a good background in mathematics for teaching and research in Mathematics, Statistics, Computer Sciences and related areas. The teaching and training division is undertaking a multimedia research project to develop course material for introductory courses in statistics at secondary and higher secondary levels.

Recruitment of faculty and essential scientific, technical and administrative staff based on the minimal needs of the Institute is in progress. Academic leave rules have been formulated in the Institute. Further, the Council of the Institute adopted revision of the rules of the Institute governing scientific works financed by bodies other than the Institute. Certain medical benefits for the retired colleagues of the Institute were introduced.

The International Statistical Education Centre (ISEC) is run by the Institute as an Associate Body/Institution under the Memorandum of Association of the Institute jointly with the International Statistical Institute under the sponsorship of the UNESCO and the Government of India since 1950. During 1998-99 the Centre conducted its fifty-second term with 16 foreign trainees. The fellowships under the Special Commonwealth African Assistance Plan (SCAAP) of Government of India which were withdrawn from the ISEC during the last few years have been reintroduced and several candidates were admitted under the SCAAP/ ITEC programmes.

As far as the Non-plan grant for 1998-99 is concerned, increase has been given by the Government for payment of revised salaries to non-faculty and faculty workers including those in the library, except arrears for retired workers and pensioners, subsequent upon the revision by the Council of the Institute of non-faculty pay scales based on the Fifth Central Pay Commission and faculty pay scales based on UGC and other Pay scales and the Government of India decisions in these regard. The approved plan budget for 1999-2000 is exactly the same as that approved for 1998-99 by the Government.

Construction of the New Guest House, a long felt need, at Calcutta has been completed in December 1997 and several International and National Conferences/Workshops held from January 1998 onwards used this facility extensively. An additional floor of the hostel building at Bangalore Centre has been constructed. The construction

of an Administrative Building at Delhi Centre is making good progress and is to be completed by December 1999. Equipment for modernisation of the printing press has been bought. Upgraded Internet connections for research

work were installed at the Head Quarters at Calcutta, as well as at the Centres in Delhi and Bangalore. The campus wide computer networking at Calcutta using optical fibre was completed. The PCM Museum & Archives is expected to be completed in the financial year 1999-2000. Several new constructions at Calcutta including those of Faculty Quarters, Bank and Post-Office Building, New Academic Building and Canteen Building have been started.

Passion for Quality should permeate all aspects of human life and organisations. In the new environment and in the next millennium, the Institute has a dynamic role to play in the furtherance of the excellence of the Institute in the emerging areas of research, including Environmental Statistics, Small Scale Industries, Ecology etc. especially relating to the national development and social and human welfare. Our Institute is nationally and internationally recognised as a centre of excellence both for its contributions to theoretical and applied statistics, mathematics, economics and computer sciences and social and natural sciences and interdisciplinary research areas as well as for their applications and several interfaces of Statistics-Industry, Statistics-other sciences, Statistics-Interdisciplinary research, Statistics- Planning, Governmental efforts and welfare of the society, Statistics - Computer sciences and information technology, Statistics in the Era of Computing. We all pledge to uphold the standards and keep the banner of recognition high. "UNITY IN DIVERSITY" has been our motto. "PASSION FOR QUALITY" should permeate all our activities. Statistics as a key technology has a more dynamic role to play in the next millennium.

March 31, 1999 S. B. RAO

Part I. Teaching and Training, Convocation, Research and Publications

1. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities of the Teaching and Training Division during the period from April 1998 to March 1999 is given below :

During the academic session 1998-99, a total of 8164 candidates applied for admission and were called for written selection tests for the various courses offered by the Institute, viz., B.Stat. (Hons.), M.Stat. (M-stream and S-stream), Master of Science (M.S.) in Quantitative Economics, M. Tech. in Computer Science, M.Tech. in Quality, Reliability and Operations Research, Two-year Part-time Post-Graduate Diploma in SQC and OR (Chennai), Research Fellowships in Statistics, Mathematics, Economics, Computer Science and Communication Sciences, Theoretical Computer Science, Theoretical Physics and Applied Mathematics, Anthropology, Geology, Sociology, Biometry and Statistical Quality Control and Operations Research, One Year Part-time Course in Statistical Methods and Applications and the Certificate/Diploma course in Computer Programming and Applications. Admission tests were conducted at 21 different centres spread all over the country. A total of 6260 candidates finally appeared for admission tests and a total of 527 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 200 candidates were offered admission to various courses.

The number of candidates admitted to the different degree, diploma and training courses in 1998-99 and the number of students who passed in the annual examinations in 1998 are given below.

Thirty two trainees in Engineering and Technology from various Universities/ Institutes like (i) Indian Institute of Technology, Kharagpur (ii) Indian Institute of Technology, Mumbai,(iii) Vallabhbhai Regional of Engineering & Technology, Surat (iv) Regional Engineering College, Rourkella, (v) University College of Engineering,Burla, Sambalpur (vi) Indian Institute of Science & Information Technology, Bhubaneswar (vii)Assam Engineering College, Guwahati, (viii) Regional Engineering College, Durgapur, (ix) Jadavpur University, (x) Utkal University, (xi) Jorhat Engineering College, (xii) Nagarjuna University, (xiii) Indira Gandhi Institute of Technology, Sarong, (xiv) PVR & JC College of Engineering, Guntur, received a two-week/six-week/six months M.C.A. Engineering/practical training in Computer Science in the different units of the Institute.

Development of multimedia-based teaching aids

The Teaching and Training Division has started a project on developing multimedia-based presentations for instructional purposes. In the first year of the project, a multimedia laboratory has been set up with three computers, two printers, some audio-visual equipment and some software. The production of a presentation on Introductory Statistics for school students has started. A twelve-minute pilot module has been developed. When completed, this presentation is expected to help school teachers in explaining the basic concepts of statistics to their students, and to popularise the subject among school students. In a related work, the multimedia laboratory has created a poster highlighting the various features of the B.Stat (Honours) course. Several thousand copies of this poster were mailed to various high schools in the country.

Indian Statistical Institute

NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

	Course	Number of students	
		Passed in 1998	Enrolled in 1998-99
	(1)	(2)	(3)
Degree			
1.	Bachelor of Statistics with Honours [(B.Stat. (Hons.)]		
	1st year	20	25
	2nd year	13	20
	3rd year	36	13
2.	Master of Statistics (M.Stat.)		
	1st year (M-stream)	--	10
	1st year (S-stream)	34	47
	2nd year	43	34
3.	Master of Science in Quantitative Economics (M.S.)		
	1st year	16	22
	2nd year	15	16
4.	M.Tech. in Computer Science		
	1st year	25	32
	2nd year	26	25
5.	M.Tech. in Quality, Reliability and Operations Research		
	1st year	12	13
	2nd year	12	12
Certificate/Diploma			
6.	Course on Operation and Programming of Automatic Data Processing Equipment		
	1st year	---	--
	2nd year	14	--
7.	Computer Programming and Applications		
	1st year	15	10
	2nd year	--	13
8.	Part- time Certificate/Diploma Course tatistical Quality Control and Operations Research		
	Chennai -		
	1st year	--	--
	2nd year	--	

	(1)	(2)	(3)
9.	Course in Documentation and Information Science (Bangalore)		
	1st year	-	6
	2nd year	6	6
10.	One Year Part-time Course in Statistical Methods and Applications		
	Calcutta	11	15
	Delhi	--	--
	Hyderabad	--	--
11.	Six-month Part-time Course in Statistical Quality Control		
	Bangalore [July.-Dec. 1997]	12	15
	Bangalore [January - Dec. 1998]	20	21
	Hyderabad [July - Dec. 1997]	14	--
12.	Intensive Course in Programming and Applications of Electronic Computers	14	--
13.	(a) Statistical Assistantship [Nov. 1997]	--	01
	(b) Junior Diploma in Statistics [April 1997]	01	31
	(c) Senior Diploma in Statistics [Nov. 1997]	--	05
Fellowships			
14.	Junior and Senior Research Fellows, and Research Associates in different disciplines	08	31*
	GRAND TOTAL :	367	423

*Number of scholars who joined in 1998.

Indian Statistical Institute

Ph.D. Degrees Awarded in 1997

(A) Ph.D. Degrees awarded by the Institute :

i) Dipak Kumar Manna : "On CTV Minimization in Single Machine Scheduling"
Supervisor : V. Rajendra Prasad, ISI, Bangalore

ii) Kaushik Bhattacharya : "Employment Fluctuation in Rural India : A Statistical Analysis with special reference to Maharashtra"
Supervisor : D. Coondoo, ISI, Calcutta

iii) Srabani Sengupta : "New Topologies and Parallel Algorithms for static interconnection Network"
Supervisor : B.P. Sinha, ISI, Calcutta

iv) Punam Kumar Saha : "On Three Dimensional Digital Topology and its Applications to Image Processing"
Supervisor : D. Dutta Majumder, ISI, Calcutta

v) Srinivasan Balaji : "Recurrence and Transience of Reflecting Diffusions"
Supervisor : S. Ramasubramanian, ISI, Bangalore

vi) Rama Rawat : "The Pompeiu Problem and Analogues of the Wiener Tauberian Theorem for certain Homogeneous Spaces"
Supervisor : A. Sitaram, ISI, Bangalore

vii) Sudeshna Basu : "The Asymptotic Norming Properties and Related Themes in Banach Spaces"
Supervisor : A.K. Roy, ISI, Calcutta

viii) Saswati Bhattacharya : "Some Problems in Estimating Finite Population Total and Variance in Survey Sampling"
Supervisor : P. Mukhopadhyay, ISI, Calcutta

ix) Jayati Ghoshal : "Neoro Fuzzy Reasoning for Pattern Classification & Object Recognition"
Supervisor : K.S. Roy, ISI, Calcutta

x) Neeta Pandey : "The Fixed Point Index as a Local Lefschetz Number"
Supervisor : K.K. Mukherjea, ISI, Calcutta

xi) Rudrapada Sarkar : "Wiener Tauberian Theorems on Semisimple Lie Groups"
Supervisor : S.C. Bagchi, ISI, Calcutta

xii) Umapada Pal : "On the Developoment of an Optical Character Recognition (OCR) system for printed Bangla script"
Supervisor : B.B. Chaudhuri, ISI, Calcutta

xiii) P.K. Ratnakumar : "On Some Problems Related to Hermite and Laguerre Expansions"
Supervisor ; S. Thangavelu, ISI, Bangalore

(B) Ph.D. degrees awarded by other Universities to the Research Fellows of the Institute :

i) Sojen Joy : "Kinematics of Deformation and Quartz C axis fabric in a part of the Singbhum Shear Zone and its Footwall, Singbhum District, Bihar"
Supervisor : Dilip Saha, ISI, Calcutta
(Awarded by Calcutta University)

ii) Madhusree Ghosh Dastidar : "A Study on the Correlates of Morality in Two Religious Groups Inhabiting Calcutta Slums"
Supervisor : Ranjan Gupta, ISI, Calcutta
(Awarded by Calcutta University)

iii) Mita Misra : "Food Practices in some Contrasting Populations of Southern West Bengal, India
Supervisor : Amitava Basu, ISI, Calcutta
(Awarded by Calcutta University)

iv) Biswanath Sarkar : "Biological Anthropology of the Onge : A Negrito Isolate of the Andaman Island, India"
Supervisor : K.C. Malhotra, ISI, Calcutta
(Awarded by Calcutta University)

v) A.R. Chakraborty : "Software Quality Testing and Remedies"
Supervisor : T.S. Arthanari, ISI, Bangalore
(Awarded by IISc., Bangalore)

vi) Bhaswati Bhattacharyya : "Longitudinal Growth Study of two Freshwater Indian Major Carps, *Catla catla* and *Cirrhinus mrigala* Reared in the pond and in controlled laboratory conditions during the early stages of their development"
Supervisor : T.K. Basu, ISI, Calcutta
(Awarded by Jadavpur University)

Ph. D. Degrees Awarded in 1998

(A) Ph. D. Degrees awarded by the Institute :

1. Tridib Kumar Dutta : "Construction of some Combinatorial Designs Arising out of Statistical Experiments"
Supervisor : B.K. Roy, ISI, Calcutta

2. Sriparna Bandyopadhyay : "On Lipschitzian INS and connected Matrices in Linear Complementarity Problem"
Supervisor : T. Parthasarathy, ISI, Delhi

3. Debasish Das : "Static Interconnection Networks and Parallel Algorithms for Efficient Problem Solving"
Supervisor : B.P. Sinha, ISI, Calcutta

4. Sanghamitra Bandyopadhyay : "Pattern Classification using Genetic Algorithms"
Supervisor : S.K. Pal, ISI, Calcutta

5. Diganta Mukherjee : "Essays on Deprivation, Poverty and Well being"
Supervisor : S.R. Chakravarty, ISI, Calcutta

6. Biman Chakraborty : "Multivariate and Regression Analysis Based on the Geometry of Data clouds"
Supervisor : P. Chaudhuri, ISI, Calcutta

7. Sreela Gangopadhyay : "Studies in Strategic Probability"
Supervisor : B.V. Rao, ISI, Calcutta

(B) Ph.D. degrees awarded by other universities to the Research Fellows of the Institute :

1. Debashis Bhattacharya : "The Saraks : Study of a little known community in Purulia, West Bengal"
Supervisor : P. Chakraborty, ISI, Calcutta
(Awarded by Calcutta University)

2. Natabar Shyam Heman : "The Changing Patterns of Resource use and its Biosocial Implications : An Ecological Study among the Gangtes of Manipur"
Supervisor : B.M. Reddy, ISI, Calcutta
(Awarded by Calcutta University)

3. Sampa Roy (Bhattacharya) : "Observations of Fibro Calculous Pancreatic Diabetis (FCPD)"
Supervisor : S.Gupta, ISI, Calcutta
(Awarded by Calcutta University)

4. Padma V. Upadhyay : "Development Information Support to Rural end users"
Supervisor : I.K.Ravichandra Rao, ISI, Bangalore
(Awarded by Mysore University)

5. Geetha Seetharam : "Science Indicators to Study and Analyse the Scientific Literature in Food Science and Technology with and Emphasis on CFTRI's Research Publications'
(Supervisor : I.K. Ravichandra Rao, ISI, Bangalore
(Awarded by Mysore University)

6. Sarmishtha Das : "Chemical Characterization and Utilization Potential of some Lignocellulosic Plant Wastes with special reference to LP Technology"
Supervisor : S. Chanda, ISI, Calcutta
(Awarded by Calcutta University)

International Statistical Education Centre (ISEC), Calcutta

The International Statistical Education Centre was established in 1950 and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre functions under a Joint Board of Directors. Professor P.C. Mahalanobis was the Chairman since the inception of the Centre in 1950 until his death in 1972. Since then Professor C.R. Rao has been the Chairman of this Board.

The Centre provides training in Theoretical and Applied Statistics at various levels to selected participants from the countries in the Middle-East, South and South-East Asia., the Far East and the Commonwealth countries in Africa.

The Centre offers a ten-month (June to March) Regular Course of training every year. The Course is divided into two parts. The first eight months are devoted to training on general statistical methods including a six-week training in Official Statistical Systems conducted by the Central Statistical Organisation, Government of India, New Delhi. During the remaining two months, each trainee specializes in one selected branch of applied statistics, like Large Scale Surveys, Data Processing, Economic Planning, Statistical Quality Control and Operations Research and Vital Statistics and Demography. The course comprises lectures, practical work and assignments, field visits, and guided reading.

In addition to the Regular Course, a few persons are admitted on an individual basis, for special courses of varying durations and in different subject-fields.

Operations Research and Vital Statistics and Demography. The course comprises lectures, practical work and assignments, field visits, and guided reading.

In addition to the Regular Course, a few persons are admitted on an individual basis, for special courses of varying durations and in different subject-fields.

ISEC successfully completed its training program of 52nd term of the Regular Course. This year, there were sixteen trainees from nine countries viz. Sri Lanka (1), Maldives (3), Philippines (1), Cambodia (3), Bhutan (1), Korea (1) Myanmar (1), Nepal (2) and Uganda (3). All of them have successfully completed the course and have been awarded Statistical Training Diplomas. Only one trainee from Mangolia has been admitted to the special course. This course will continue till March 2000.

Professional Examinations in Statistics

The Indian Statistical Institute holds Professional Examinations in Statistics in the theory and practice of analysis of statistical data for external candidates for the award of the following diplomas :

1. Junior Diploma in Statistics
2. Senior Diploma in Statistics

These examinations are separate from, and independent of the examinations held for the award of degrees, diplomas and certificates on the basis of training given by the Institute.

The Government of India recognises the Junior Diploma in Statistics as equivalent to Bachelor's degree in Statistics and the Senior Diploma in Statistics as equivalent to a Master's degree in Statistics.

These examinations are held now-a-days twice in a year usually around April/May and November/December at different cities in India (Bangalore, Calcutta, Chennai, Delhi, Hyderabad, and Mumbai).

Shown below are the details regarding the registered candidates for the June 1998 term.

	Number of candidates (in June 1998)		
Examination	Registered	Appeared	Passed
1. Junior Diploma in Statistics (JDS)	63	31	16
2. Senior Diploma in Statistics (SDS)	8	5	1

The number of `Passed' candidates refers to those who passed in one or more papers, not only those who completed the examination. The numbers of candidates enrolled for the May 1999 term are 56 and 5 for JDS and SDS, respectively.

Preparation of the model -answer booklets for the compulsory papers in Senior Diploma in Statistics and two papers of Junior Diploma in Statistics is also under way.

The cumulative total number of candidates who have qualified for the award of the Diplomas in the Professional Examinations in Statistics including those who qualified in June 1998 term is 281.

2. CONVOCATIONS

Thirty second convocation

Indian Statistical Institute held its Thirty Second Convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech (Quality, Reliability and Operations Research), M.Stat., B.Stat. (Hons) degrees and Diplomas, Associateship etc. on 29 June 1998.

Professor M.G.K. Menon, FRS, President of the Institute presided over the Convocation and awarded Degrees, Diplomas, Associateships and Awards to the students. Professor S.B. Rao, Director of the Institute presented the annual review of teaching & training activities of the Institute. Hon'ble Justice Shri M.N. Venkatachaliah, Chairperson, National Human Rights Commission, delivered the convocation address.

The numbers of students who obtained Degrees, Diplomas, Associateships and Awards in the Convocation are given below :

Degree/Diploma/Associateship	Number of candidates
Doctor of Philosophy (Ph.D.)	13
Master of Technology (M.Tech.) in Computer Science	22
Master of Technology (M.Tech.) in Quality, Reliability & Operations Research	12
Master of Statistics (M.Stat.)	48
Bachelor of Statistics (Hons.) [B.Stat. (Hons.)]	29
Associateship in Documentation & Information Science	8
Diploma on Operation & Programming of Automatic Data Processing Equipment	12
Part Time Diploma in Statistical Quality Control & Operations Research, Chennai	4
Professional Examinations in Statistics	
Junior Diploma in Statistics	1
Total :	149

AWARDS

1. Award of Mahalanobis International Symposium on Statistics Prize to the most outstanding M.Stat. student of the Institute :

Lakshmi Iyer

2. Award of ISI Alumni Association and Mrs. M.R. Iyer Memorial Prizes to outstanding students of the Institute :

B.Stat. (Hons) : Debashis Paul
M.Stat. : Partha Sarathi Chakraborty
M.Tech.(CS) : Debashis Sarkar.

Thirty third convocation

Indian Statistical Institute held its Thirty third convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech (Quality, Reliability and Operations Research), M.Stat., B.Stat. (Hons.) degrees and Diplomas, Associateship etc., on 02 February, 1999.

Professor M.G.K. Menon, FRS, President of the Institute presided over the Convocation and awarded Degrees, Diplomas, Associateships and Awards to the students. Professor S.B. Rao, Director of the Institute presented the annual review of teaching & training activities of the Institute. Sir Walter Fred Bodmer, FRC Path, FRS, Principal, Hertford College, Oxford delivered the convocation address. In his address Sir Bodmer highlighted how Statistics plays a key role in understanding the fundamental nature of the disease and how it may help in the research towards preventing and treating cancer.

The numbers of students who obtained Degrees, Diplomas, Associateships and Awards in the Convocation are given below.

Degree/Diploma/Associateship	Number of candidates
Doctor of Philosophy (Ph.D.)	7
Master of Technology (M.Tech.) in Computer Science	23
Master of Technology (M.Tech.) in Quality, Reliability & Operations Research	13
Master of Statistics (M.Stat.)	28
Bachelor of Statistics (Hons.) [B.Stat. (Hons.)]	15
Associateship in Documentation & Information Science	36
Diploma on Operation & Programming of Automatic Data Processing Equipment	5
Part Time Diploma in Statistical Quality Control & Operations Research, Chennai	14
Professional Examinations in Statistics	
Junior Diploma in Statistics	1
Total :	142

AWARDS

1. Award of Mahalanobis International Symposium on Statistics Prize to the most outstanding M.Stat. student of the Institute :

Arnab Chakraborty

2. Award of ISI Alumni Association and Mrs. M.R. Iyer Memorial Prizes to the outstanding students of the Institute :

B.Stat. (Hons) : Gopika Ranjan Goswami
M.Stat. : Antar Bandyopadhyay

3. Award of ISI Alumni Association Rashi Ray Memorial Medal and M.R. Iyer Memorial Prize for outstanding performance in M. Tech. in Computer Science.

Nirmalya Barat

4. Award of ISI Alumni Association Prize for outstanding performance in M. S. in Quantitative Economics.

Sayandeb Banerjee

3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

The major thrust of the Institute is on research in various disciplines comprising Theoretical and Applied Statistics, Mathematics, Computer Sciences, Biological Sciences, Economics and other Social Sciences, Physical and Earth Sciences, Statistical Quality Control and Operations Research and Library, Documentation and Information Sciences. Scientists of the Institute carry out independent research in their own basic discipline and also undertake interdisciplinary research in collaboration with other units within the Institute and also with outside organisations. The Institute also takes up various internally and externally funded projects in diverse fields on challenging live problems of national and international importance. As a part of research activities, scientists of the Institute are involved in consultancy work as well. For academic and administrative convenience, a number of Divisions (each division having one or more units) have been formed which are listed below :

1) Theoretical Statistics and Mathematics

2) Applied Statistics

3) Computer and Communication Sciences

4) Physics and Earth Sciences

5) Biological Sciences

6) Social Sciences

7) Statistical Quality Control and Operations Research

8) Library, Documentation and Information Science

In addition, there is a well equiped Computer and Statistical Services Centre (CSSC) which manages the central computing system, e-mail and internet facilities and provides computing and statistical services to researchers.

Computer networking within the Institute at Calcutta has been completed and researchers, students, scholars etc. can now access the computing facilities from any terminal. The network provides computing on Vax 8650, Sun Ultra, DEC Alpha, SGI and IBM AS400 platforms. As a part of computer networking, all faculty members have been provided with individual PCs, connected to the network, in their offices. Delhi and Bangalore Centres of the Institute have also similar facilities.

A brief account of the research activities in different divisions and units during the year is given below :

Theoretical Statistics and Mathematics Division

The Division with units in Calcutta, New Delhi, Bangalore and Hyderabad has a major role in teaching Probability, Statistics and Mathematics in the B. Stat. (Hons.), M. Stat., M. Tech. (QR & OR) and other courses of the Institute. The Division also conducts courses for 3-4 semesters at an advanced level for research fellows enrolled for Ph. D. degree of the Institute. The unit in Calcutta regularly conducts a weekly colloquium with speakers both from within the unit and outside. The Division regularly conducts workshops, summer / winter schools, refresher courses and conferences with extensive interaction from academics from various organizations both in India and abroad, funded by external agencies as well as by the Institute. The research activities of the Division are in Probability Theory, Theoretical Statistics, Stochastic Processes, Mathematical Stochastic Modelling and various branches of pure mathematics such as Algebra, Functional analysis, Combinatorial theory, to mention some broad areas. Several members also provide statistical consultation to other units in ISI or other organizations.

Some of the areas of research and contributions from various units are given below :

Calcutta Unit

The faculty members are actively engaged in research and applications. The Unit also undertook several projects.

Research Activities

Theoretical Statistics

The major areas of research were: Asymptotic theory in Statistics, Sequential Analysis, Bayesian Inference, Ranking and Selection, Cramer-Rao type Integral Inequalities, Multivariate Analysis, Non-parametric Inference, Inference in Stochastic Processes, Directional Data Analysis, Optimal Designs and other aspects of experimental designs, Survey Sampling, Survival Analysis, Time Series Analysis, Bootstrap, Jackknife and other resampling techniques, Parametric and nonparametric regression techniques and related topics, Bayesian nonparametric statistics and estimation, Bayesian semiparametric inference and inference with many nuisance parameters, Robust Bayesian Analysis, Reliability theory, Applications of statistical and graph theoretic techniques to Social and Biological Sciences.

Some major contributions during the year 1998-99 are described below.

Theoretical research on the rates of CLT and allied topics continued. Some applied problems related to quality control were solved.

Research on flexible and adaptive discriminant analysis continued; analysis of data related to the spread of malaria in Calcutta in recent years has been undertaken. The use of weighted likelihood in problems of classification and discrimination and the use of divergence measures for studying robustness in the context of testing were looked into.

Research work on intrinsic Bayes factors, model selection and Bayesian nonparametrics was continued and major new results were obtained.

Weighted bootstrap for non-linear models, including the problems of M-estimation, generalized linear models and non-linear models were studied. First order consistency of the weighted bootstrap techniques has been established; higher order results are being studied. Also, dimension asymptotic results have been established in the context of weighted bootstrap in linear as well as non-linear models.

Methods of estimation for small areas/domains were suggested for decentralised planning at panchayat and gramsabha levels. Theoretical work was done on utilisation of auxiliary information in PPS without replacement schemes such as Rao-Hartley-Cochran scheme. Innovative methodologies were tried out in a project on sampling of mobile populations such as *hats* (weekly village markets), temple visitors etc.

A study was undertaken on Statistical Exploration of Homogeneous and Hierarchical Structures in DNA data. The main focus was on Phylogenetic Analysis of various nucleic acid sequences available in DNA Data Bases accessible through the Internet. Some significant progress has been made towards development of novel statistical methodology for efficient analysis of large volumes of genomic sequence data. A software called SWORDS (Statistical Analysis of Words in DNA Sequences) was developed for analyzing various patterns reflected in the distribution of words in a DNA sequence and their phylogenetic and other biological implications.

In the field of Neural Networks, the convergence of back-propagation algorithm has been studied in the case of complex boundaries. A technique has been proposed for cleverly picking up training samples without knowing the actual position of decision boundaries and a training set, thus formed, improves the performance of the algorithm. Also a method based on a Neural Gas Network model has been proposed for the extraction of vector skeleton of volumetric images of filamentous bacteria. The proposed method is sufficiently robust with respect to presence of noise and rotation.

Probability Theory and Stochastic Processes

The major areas of work were: Limit theorems, Rates of convergence and expansions, Stochastic Integrals, Markov Processes and Dynamical Systems, Stochastic Differential Equations, Polynomial Martingales, Random Walks, Finitely Additive Probability, Probability inequalities and Stochastic majorisation, Martingale theory and Stochastic calculus, Markov Chain simulation.

The following paragraphs give a brief description of the important contributions made during 1998-99.

Work on time-space harmonic polynomials associated with stochastic processes was continued. Work in percolation theory is continuing. Completeness of Lp-spaces in the finitely additive setup was discussed. The relation between the method of random union of gametes and the method of mating matrices in evolutionary theories was studied. A study of the Markovian algorithm for random continued fraction expansions was undertaken and invariant measures found. Complete characterization of Markovian motions, that evolve only through velocity changes allowing only finitely many changes in finite time, was obtained.

A regular weekly seminar in probability theory was started and is expected to continue. The idea is to get acquainted with areas of current research interests in probability theory and stochastic processes.

Mathematics

The major areas of work were: Commutative Algebra, Geometry of Banach Spaces, General Topology, Algebraic and Differential Topology, Topology with emphasis on Function spaces, Equivariant plus construction and acyclic maps, Gromov theory on partial differential relations, Quantum groups, Uncertainty principles on Nilpotent and Solvable Lie groups, Wiener Tauberian Theorems in Semisimple Lie groups, Equivariant Cobordism, Stochastic Differential Geometry, Descriptive Set Theory, Automata Theory, Theoretical Computer Science, Harmonic Analysis, Ergodic Theory, Functional Analysis, Operator Algebras, Differential Geometry, Spectra of Laplacians, Sediment Transport, Graph Theory, Combinatorics and Construction of Designs.

Some major contributions made during 1998-99 are as follows.

A structure theorem for an A^*-fibration over a one-dimensional noetherian seminormal semilocal domain has been proved. It has been shown that, in the above situation, any A^*-fibration whose spectrum occurs as an affine open subscheme of the spectrum of an affine line A^1, is actually A^*. The results provide examples of A^*-fibrations over one-dimensional noetherian seminormal semilocal domains whose spectra are not affine open subschemes of any affine line A^1 over the base ring. Examples have also been constructed of non-trivial A^*-fibrations over one-dimensional noetherian non-seminormal local domains whose spectra are open subschemes of A^1-fibrations over the base ring.

Intrinsic characterizations for uniquely extending bounded linear functionals from subspaces to the full space, characterizing U subspaces, i.e. subspaces Y for which all y^* in Y^* have unique norm preserving extensions, and the relationship of these to W^*-asymptotic norming properties of Banach spaces (considered by Hu and Lin) were studied.

The study of dual spaces of some function spaces has been elaborately carried out. The study made use of important results from both Functional Analysis and Measure Theory and few of the characteristic features have been observed. The study is continuing.

The nature of the group of equivariant self homotopy equivalences of a G-space was studied. The work (with P. Sankaran of Chennai Mathematical Institute) to determine which groups act chaotically on the Euclidean spaces is in progress.

The restrictions of an equivariant Morse function on a G-manifold to its fixed point sets were studied to determine whether these restrictions when considered as non equivariant functions effectually describe the equivariant Morse function.

Work on some problems in Descriptive Set Theory, particularly related to Polish Group Actions, counting the number of equivalence classes, etc. continued.

Work on harmonic analysis centred around some questions on a topic of current interest, the so-called Uncertainty Principles in the setting of Nilpotent and Semisimple Lie groups. In particular, a transparent parametrisation for step-two nilpotent Lie groups was worked out which helped to resolve several of the questions.

In theoretical computer science, work on exact and approximate solutions of selected NP-hard optimization problems continued. Some interesting positive and negative results have been obtained, concerning approximate solutions of linear ordering problems with weight matrix satisfying parametrized triangle inequality. Some results have also been obtained concerning complexity of optimal evaluation ordering problem as well as simple heuristics for MAXCUT problem.

Some contributions to the studies of multidimensional cellular automata and interval logic have been made.

Projects Undertaken

Statistical Exploration of Homogeneity and Hierarchical Structures

A statistical software called SWORDS (Statistical Analysis of Words in DNA Sequences) has been developed for analyzing and comparing large DNA sequences. The software can carry out cluster analysis leading to the discovery of phylogenetic and evolutionary patterns in DNA data and validate such statistical findings using resampling techniques such as the bootstrap and the jackknife. Complete mitochondrial DNA sequences available in the public domain data bases accessible through internet for several mammals, fish, amphibia and two controversial fish: coelacanth and lungfish have been analyzed using SWORDS. The analysis casts new light on vertebrate evolution and phylogenetic positions of coelacanth and lungfish. A detailed statistical analysis of complete genome of the round worm (C. elegans) consisting of six chromosomes is being carried out using SWORDS. The data on this genome was made available in the internet only recently and the statistical analysis using SWORDS might reveal facts that are of significant importance to molecular biologists.

Winter School on Statistical Methods in Medicine, Public Health and Environment.

The School conducted during 26 October 1998 to 18 November 1998, was aimed at medical practitioners, nutritionists, environmentalists, biologists etc. About 30 participants from all over India took part in the program. The course was structured to explore the interaction between these different disciplines and Statistics. Quite a number of participants presented their case studies. The participants were grouped according to the similarity of their problems and were led by an expert in that field. The participants were given a thorough course on the different statistical techniques used in these topics. Much emphasis was given to the use of available computer softwares. Apart from the faculty from the different units of ISI, Prof. A. P. Gore (University of Pune), Prof. Banshi Badan Mukhopadhyay (Burdwan Medical College) and Prof. Kanai Lal Mukherjee (Deputy Director, CMDA, previously Professor and Head of the Department of Preventive Social Medicine, R.G. Kar Medical College) participated in the teaching.

Winter School on Transformation Groups

One of the research activities of the Institue in Topology is centered around the study of geometric properties of topological spaces using transformation groups. The Winter School was organized with a view to bring together mathematicians from other Institutions in India, who are actively involved in the study and research in these areas so that dissemination of current results and exchange of ideas could take place. The School aimed to impart to young researchers some modern techniques of transformation groups as applied to topology, geometry and combinatorics. About 25 young research scholars and teachers from various Institutes and Universities of India have attended the School. Also, about 15 distinguished topologists from various universities and Institutes of India and abroad visited the Stat.-Math. Unit to take part in the discussion and to give lectures in the Winter School organised during 8 December 1998 to 26 December 1998. The main speakers in the School were: Prof.

Satya Deo Tripathi (University of Rewa, M.P), Prof. Chris Allday (Univ. of Hawaii, USA), Prof. Mikiya Masuda (Osaka University, Japan), Prof. D. Gauld (Univ. of Auckland, NZ), Prof. V. Srinivas (TIFR, Mumbai), Prof. R.V. Gurjar (TIFR, Mumbai), Prof. P. Sankaran (SPIC, Chennai), Prof. A. Mukherjee (ISI, Calcutta), Prof. T.B. Singh (Univ. of Delhi), Prof. H. Mukherjee (NEHU), Prof. S.S. Khare (NEHU) and Prof. A. Ranjan (IIT, Mumbai).

Projects funded by SURDAC

In addition to the above projects, the faculty of the Stat.-Math. Unit also collaborated with the faculty of the Population Studies Unit, Sociological Research Unit, Biochemistry Unit and the Psychological Research Unit of the Institute on projects funded by SURDAC, the Survey Research and Data Analysis Center of the Institute. Work continued on the projects entitled "Changing Social Relations: Social Network Approach", "Cervix Cancer Database: Molecular Epidemiology" and "Analysis of Academic Achievement of Primary School Children in West Bengal" and a new project entitled "Statistical methodology for Studies on Mobile Populations" was undertaken.

The SURDAC funded project on **Changing Social Relations - Social Network Approach** continued in 1998-99. During the year, the demographic changes in the village Kabilpur between 1971 and 1998 were studied and it was found that these did not have any significant impact on the change in the network relations. Data on the social network of another village, Baidyanathpur, was also collected during the year. On comparing the two villages it was observed that in the village where there had been considerable economic and political changes, the change in the network relations was also dramatic; reciprocity decreasing drastically, yet connectedness increasing both within and outside the village and new mini-pyramidal hierarchies developing. Such dramatic changes did not take place in the other village. Detailed analysis of the data from the second village is going on.

The project entitled **Statistical methodology for Studies on Mobile Populations** relates to mobile populations such as buyers at village markets (*hats*), pilgrims at a temple, etc. Certain villages have weekly (or twice weekly) *hats* where day to day necessities like food, kerosene, tobacco, clothing, etc. are sold. The project concentrated only on the retail weekly markets and tried to evolve suitable sampling designs to study such markets. Village markets are important since it is a 'social institution' wherein people come not only for their purchases but also to have social contact, exchange information on births, deaths and marriages, health status, marriage alliances, etc. Due to the effects of urbanisation, the scenario may be changing and the aim of the project was to study this. On the basis of pilot studies, two medium sized hats were selected around Barasat. Each *hat* was divided into homogeneous strata. From each stratum, two sellers (stalls) were selected at random without replacement (WOR) and data was collected on specific questions from them using a 'seller questionnaire'. The parameters of interest such as population proportions and means were estimated by conventional estimators. Next, considering only the peak period, 'buyers' were selected in two stages and information was collected from those visiting the shop in a randomly chosen time slot through a 'buyer questionnaire'. For questions relating to the size of a mobile population such as pilgrims/visitors to a temple, a pilot study was undertaken at Dakshineswar temple. The plan is to estimate the number of visitors using information such as number of shoes kept at footware keepers, whether registered or not, and number of vistitors' vehicles at suitably chosen points of time.

An account of the work done in the other two SURDAC funded projects mentioned above have been given elsewhere.

INSA Funded Project

Work continued on the INSA Funded project "Studies on Probability and Mathematical Inequalities".

Strengthening Local Government in Madhya Pradesh

The Government of India had requested Asian Development Bank for technical assistance to strengthen local government as part of the reform agenda of the state government of Madhya Pradesh. At the request of Price Waterhouse Coopers (PWC) who was one of the prime contractors to the Bank for this purpose, an inter-firm agreement between PWC and ISI was made to develop the Statistical Information System (SIS) as a part of the project asignment. The SIS is envisaged to be a statistical data base for rational decision making, specially at the local government level, taking into account the 73rd / 74th amendment of the Constitution of India in the year 1992. It is expected to address the information needed for planning at Panchayat, Janapad district at higher levels.

The work involved in developing the SIS consisted of (a) identification of required data items, (b) designing of formats of data collection,collation and compilation, (c) development of methodology of data collection, (d) specification of output formats, amenable to computerised data base, and (e) organisation of workshop in collaboration with the state government to finalise the methodology of data formats.

The project was almost completed during the year 1998-99. DCSW members of Stat.-Math., Applied Statistics and Social Sciences Divisions participated in the project.

Regional Math Olympiad

The Regional Mathematical Olympiad 1998 for West Bengal, sponsored by National Board for Higher Mathematics, for class 9, 10 and 11 students was organized on 6 December 1998 at various centers including Berhampore, Burdwan, Calcutta, Kalyani, Kharagpur, New Jalpaiguri, Purulia and Santiniketan. ISI, Calcutta was the West Bengal Centre of the Indian National Mathematical Olympiad 1999. This year Prof. S.M. Srivastava organized the RMO and the INMO. Over the years, these events have become very popular and led to a great interest and enthusiasm in Mathematics in the region. The overall performance of students from West Bengal Region this year was the best among all the regions. In all 8 students from West Bengal Region (from a total of 30) were successful at INMO-99 with an average score of 42.20 for the region.

Risk Analysis of Long Term Agreement

Recently, a team of scientists from various units of the Indian Statistical Institute, Calcutta, developed a mathematical model to analyze a coal supply agreement between a subsidiary of Coal India Ltd. and a power supply company. The purpose of the model is to provide an understanding of the pattern of coal supply in the face of various uncertainties and a realistic assessment of the net monetary risk to the coal supplier. The mathematical structure of the model was developed after studying the Coal Supply Agreement and some other agreements and after a series of extensive discussions with representatives from the Coal India Limited (CIL) and its subsidiary in question. A computer program was written in the 'C' language, based on the model, to conduct simulations on the various variables of interest.

The overall 'loss' of the CIL subsidiary during a period of about thirty years is the ultimate outcome of the model. This overall loss is regarded as a weighted sum of the losses (in Rupees) computed at the end of every month during the period of simulation. The weights are determined by the prevailing interest rates and the rate of inflation. The challenging aspects of model building were the inter-dependence of the various variables because of operational realities, the intricacies of the legal conditions documented in the coal supply agreement and existence of various decision variables. Eventually a modular programme was prepared such that the controls sought by CIL were available in the form of input parameters. The final Model for Analysis of the Supply of Coal (MASC) as well as the programme was handed over to CIL for sensitivity analysis with respect to various factors of interest.

Delhi Unit

Research Activities

Probability

Work has been done on Filtering Theory using the Martingale problem techniques. While focusing on the problem of asymptotic behaviour of the filter, it was shown that the filter is a Feller Markov process. While this result is known in the special case when the filter is the unique solution to the Zakai/FKK equations of filtering, the approach taken up shows that this result is true in a wider framework and is deduced without any reference to the equations of filtering. The Markov property enables one to take recourse to the semigroup theory and its interplay with ergodic theory. Using these techniques, it was deduced that the filter as well as the observation along with the filter (with a wrong) initial condition are Ergodic Markov processes. This observation is important from the point of view of robustness of the filter.

Recently, there has been a lot of interest in the filed of Mathematical finance. The relationship between Absence of Arbitrage and existence of equivalent martingale measures has been investigated. The equivalence of the two has been shown using Orlicz space techniques .

Two classes of Levy processes are described-one containing homogeneous Levy processes and the other consisting of more general processes where the process can be determined by a finite family of polynomial martingale functions of the process. The exact number of polynomials required for determining a given Levy process is also obtained.

The asymptotic properties of a minimal spanning tree formed by n points uniformly distributed in the unit square, where the weight function is such that the minimal spanning tree has a "direction" of growth have been studied. It is shown that number of branches from the root of this tree, the total length of these branches and the length of the longest branch converge weakly. This model is related to the study of record values in the theory of extreme value statistics and this relation is used to obtain the results. The results also hold when the tree is formed from a Poisson point process of intensity n in the unit square.

Work has been done on two dependent models of percolation - the random stick model and the Voronoi percolation model. In the first model, the geometric stucture of the finite clusters has been studied, while in the latter, it has been shown that if the Voronoi percolation model arises from a Poisson point process conditioned to have a point in every unit square, then in two dimensions the criticality of the model is 1/2.

Work was undertaken on Characterization problems and rates of convergence of discrete approximation of stochastic intergrals, multivariance and multicorrelation, r-th order strong mixing.

Mathematics

The classical Matrix-Tree Theorem due to Kirchhoff which asserts that the number of spanning trees in a graph equals any cofactor of its Laplacian matrix has been generalized by several authors. A study was undertaken on mixed graphs, i.e. graphs in which some of the edges may be oriented and a combinatorial description of all the minors of the Laplacian matrix was obtained. The work implies a result of Chaiken describing all minors of the Laplacian matrix of an undirected graph.

A direct proof was obtained for the positive definiteness of several matrices arising in classical operater theory problems. Among them are the famous Loewner matrices introduced in 1934. This proof leads to a unified analysis of several famous inequalities.

A striking result for norms of derivatives of operator functions was proved. This says that the norm of the Frechet derivative of the r-th power of a positive operator is equal to the norm of its ordinary derivative for all values of r except those in the interval $(1, \sqrt{2})$. This work is part of an ongoing project to develop noncommutative calculus.

Faber-Kraln inequality was generalized to a class of non-linear degenerate elliptic partial differential equations.

In linear complementarity problem, one of the important questions is the following : Suppose A is a $P_0 \cap Q_0$ matrix. Then could one say that the set $S(q, A) = \{x \in R^n_+ : Ax + q \geq 0, x \geq 0 \text{ and } x^t(Ax + q) = 0\}$ is connected set for every $q \in R^n$? A partial answer to this question was given. For example if A is a non-negative, $P_0 \cap Q_0$ – matrix this question was answered in the affirmative. The following was established : if M can be partioned as : $M = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$ where A and D are square matrices and if A is a $P_0 \cap Q$ - matrix, D is a connected matrix, C is a null-matrix, then S (q, M) is a connected set for every q. Proof of this result depends on some topological theorems on weak univalence (of some function).

Research was also carried out in the following areas : Operator algebras, dynamical semigroups on them, their structures and dilation, non-commutative geometry- their relation with stochastics, spectral theory of differential operators, specifically Schrodinger operators, unbounded operators on Hilbert C* models.

Statistics :

Research was carried out in the broad area of 'Estimation of a Common Mean'. Explicit expression and properties of the unique unbiased estimator of the optimal weight for combining two normal means based on sample variances of independent samples of possibly unequal sample sizes were obtained in the more general set up of two independent observations from Gamma populations with possibly unequal scale parameters for wider applications which include extension of Olkin - Pratt results on unbiased estimation of intra-class correlation besides the common mean problem and the related problem of recovery of inter- block information. The most significant application of the results is to the normal common mean problem where it provides simultaneous improvement over both means under mildest condition on sample sizes known so far. Techniques employed involve inequalities concerning Hypergeometric function which are of independent interest.

An important result on the optimality of fractional factorial plans for arbitrary factorials was obtained. It was shown that under a hierarchical linear model involving factorial effects, if a fractional factorial plan ensures inter-effect orthogonality then it is universally optimal in the class of all plans involving the same number of sums. A combinatorial characterization of inter-effect orthogonality was also discovered.

A general procedure of constructing asymmetric othogonal arrays of arbitrary strength was discovered for the situation where each column of the array has prime power number of symbols. Most of the arrays of strength three, obtained via the proposed method are tight.

Investigations were carried out to obtain A-optimal designs for parallel line bioassays. A large number of A-optimal designs, both for symmetric and asymmetric parallel line assays have been obtained.

Work has been done on estimation of survival functions under order constraints. It was found that generally it is better to model competing risks in terms of sub-survival functions rather than in terms of cumulative incidence functions. The idea of signature of a coherent system was developed and used to compare various systems. A new concept of dispersive ordering was introduced. Work has been done on stochastic orders as applied to order statistics and concomitants of order statistics of nonhomogeneous observations. U-statistics for associated random variable were studied and strong law of large numbers and the CLT for them were derived. Some work has been done on Bayes estimation problems for Stochastic partial differential equations.

Bangalore Unit

Research Activities

Probability Theory

Major areas of research during the year 1998-99 included : Quantum probability, Diffusion processes and Skorokhod problem, semi-stable measures and processes, Chaotic dynamics on the Real Line.

Ongoing work on quantum probability continued; product systems of one-dimensional Evans-Hudson flows and minimal dilations of quantum dynamical semigroups were studied.

Statistics

Research was carried out in the following broad areas : Sample Surveys, Large Sample Theory, Bayesian Inference, Bayesian Non-Parametric Statistics, Bayesian Non-Parametric Estimation, Robust Bayesian Analysis, Reliability Theory, Optimality and construction of experimental designs.

Performance of some design-unbiased sampling strategies for estimating the mean have been compared under a regression model. Some simple implementable alternatives to sampling strategies consisting of Horvitz-Thompson estimator and *ps* design have been suggested. Problem of estimating non-negative definite quadratic forms has ben studied.

In a linear regression R^2 traditionally measures how good the fit is - in the sense of what part of the variability in the response variable can be explained using the regression. It has been shown that a similar robust Bayesian interpretation is also available.

Mathematics

Some broad ares of research during 1998-99 were : Groups of exceptional Lie type, Coxeter groups and the Monster group, Combinatorics, (Bruck-Ryser type theorems for quasi-symmetric designs and strongly regular graphs), Functional Analysis, Geometry of Banach space, Ergodic theory, Operator algebras and Operator theory, Harmonic analysis, Differential Geometry and Topology, Spectra of Laplacians (especially on Vector bundles), Spectral theory for partial differential operators, Finitely additive measures, g-inverses.

Several natural indecomposable modules associated with the symplectic group SP (4, q), q-even, and its building were studied and their structure determined.

For the space of Bochner integrable functions, the property of being constrained in the bidual has been considered. The connection between this property and Radon Nikodym property and proximinality has been investigated. Denting and strongly extreme points in the unit ball of spaces of operators has been studied; in particular it was shown that there are no denting points in the unit ball of $L(l^p)$, $p \geq 1$. Points of weak* -norm continuity in the dual unit ball of the injective tensor product spaces have been exhibited. Conditions under which spaces of operators arise as continuous function spaces have been investigated.

The work on finding a complete set of unitary invariants for quotients of Hilbert modules over function algebras continued.

In R^n, it is known that if all the spherical averages of a locally integrable function f are zero, with the centres of "spheres" coming from a suitable "small" set, then f is the zero function. This result has been generalised to the case of complete connected real analytic Riemann manifolds with an analytic metric. A beautiful result of Hardy of the impossibility of a nontrivial function on R and its Fourier transform to be both "very rapidly decreasing" has been extended to all noncompact semi-simple Lie groups.

Ongoing work on Hermite and Special Hermite expansions continued. Restriction theorems and local estimates for the Bochner-Riesz means have been obtained for Hermite operator on R^n and the special Hermite operator on C^n.

In addition to the above, expository work on Fourier analysis and Uncertainty principles was carried out; an introductory book on Linear Lie Groups and Representation Theory was also under preparation.

Applied Statistics Division

The Applied Statistics Division came into being from September 1996 in place of Applied Statistics, Surveys and Computing Division. The Computer Science Unit was re..amed as the Applied Statistics Unit. This is the only unit which is under the Applied Statistics Division at present.

Applied Statistics Unit

Scientists of the Applied Statistics Unit (ASU) are involved in various teaching, training, research and development activities. ASU is fully responsible for conducting the short-term course "Intensive Course on Programming and Application of Electronic Computers". This unit also regularly conducts teaching/training programmes like winter/summer schools and workshops. The members of the faculty conduct research in various

areas of statistics, mathematics and computer science, with special emphasis on applications. Some members collaborate with other units of ISI on joint projects. Currently, there are collaborative on-going projects with the Theoretical Statistics and Mathematics Division and the Social Sciences Division. The scientists of the unit are also actively involved in the activities of the newly formed Survey Research & Data Analysis Centre (SURDAC). A brief description of the research and project works conducted in 1998-99 is given below.

Research Activities

Sample Survey

Optimal sampling strategies were derived to estimate totals of finite populations using classical, Bayesian and empirical Bayesian approaches covering small domain problems. Relative performances of ordinary and generalized least squares estimators in survey sampling and design of experiments are simultaneously evaluated. Methods of borrowing strength across domains and over time in order to develop serviceable small domain statistics were being explored further. Model assisted strategies for estimating finite population total and mean square error of estimator of total applying asymptotic methods were developed. Some asymptotically optimal double sampling procedures were also found. A new variance estimator in three-stage sampling is proposed and found to fare marginally better than a traditional one. In connection with an actual socio-economic survey based on a stratified unequal probability sample taken in three stages, confidence intervals are worked out for total, multiple and partial correlation coefficients and total and partial regression coefficients involving upto four variables simultaneously considered. Probability distribution of the number of distinct units in a PPS with replacement sample is worked out in a closed form in order to study the properties of a Rao-Blackwellized version of Hansen-Hurwitz estimator. Properties are investigated of a general class of estimators of the ratio of two totals based on general complex sampling designs using multivariate data.

Design of Experiments, Combinatorial Methods and Their Applications

Cross-over designs have been studied under non-additive non-circular models, with higher-order carry-overs. The analysis has been developed using Kronecker Calculus; optimum designs have been obtained; and the construction problem has been solved completely. These results were shown to be robust under the random-patient-effect model.

The problem of obtaining cross-over designs with fewer subjects and fewer time periods than the existing designs is being studied. Some small and efficient designs have been obtained. The robustness of these results is being investigated under mixed models.

Strongly balanced uniform repeated measurement designs have been constructed in the linear and in the circular cases. Concepts generalising nearly balanced URMD's and second order RMD's are introduced. Such designs have been constructed for some classes of parameters. The problem in its full generality is under investigation. Combinatorial aspects of designs were studied particularly with respect to characterising the well known class of lambda designs. Some characterisations have been obtained under structural and parametric conditions.

Multivariate Analysis

The probability inequality $P(A \cap B) > P(A) - P(B)$ applicable in two dimensions for convex and coordinatewise symmetric sets under the Gaussian distribution is shown to be true for higher dimensions for sets with special structures.

Work on semi-parametric classification rules subsuming the logistic discrimination rule of Cox is being done through a generalization of pseudo-MLE approach. Applications include many standard multivariate distributions and a variety of bivariate reliability models. Optimal tests were derived for no-contamination in multivariate mixture models. Neymann's C_α - test was generalized to multiparameter two-sample case and its application to change-point problems is being studied.

Inference

Robust methods based on minimum distance techniques are being developed for iid situations as well as more general regression set-ups. Recent advances include the development of a new class of divergences outside the scope of "disparities" and related inference. New weighted likehood procedures based on minimum distance estimating equations applicable in robust estimation and outlier detection have been developed. Robust tests for equality of variances were developed. A new 'set estimator' useful in describing the external shape of a point set has been constructed.

Generalized Regression

Likelihood based and estimating equation based methods for nonparametric regression have been developed in multiparameter and multiresponse situations with some analysis of simulated and real life data.

Linear Models

In continuation of earlier work on collinearity in the linear model, the numerical conditioning of subset models was studied. Specifically, bounds on the smallest positive singular value of the design matrix of a subset model were obtained. Search algorithms for identifying numerically well-conditioned subsets were explored and evaluated through simulations.

The updates in the General Linear Model for data and model changes were examined in terms of the linear zero functions. This approach led to interesting interpretations of the correction terms.

Reliability, Life Testing and Survival Analysis

Studies are being carried out on the analysis of competing risk data with cause of death arbitrarily missing. Estimation procedures using EM algorithms have been worked out. A counting process approach is under study in the context. Some robust and nonparametric methods of estimation of the number of components in a system of superimposed renewal processes are being worked out. Progress has also been made in the calculation of system reliability under various stress-strength models.

The problem of designing the optimal examination time in a simple illness-death model on the basis of a computationally simple criterion has been solved. This work has possible application in cancer screening studies.

A regression model for survival data was developed for situations where conventional regression models such as the proportional hazards model do not work. The new model, called the *Proportional Reverse Hazard Model* was used to analyze incubation periods of transfusion related AIDS.

Biostatistics

Distributional results have been obtained and methods of analysis developed for correlated, repeated observations on a single subject in dealing with skin papilloma.

A test for checking homogeneity across groups using Poisson count data has been developed, with application in cancer studies involving tumor counts.

The possible association between multiple hospital admissions with respiratory problems and air pollution has been studied using case-crossover design and a Poisson process approach.

A preliminary study on projection of HIV incidence in Calcutta based on limited survey information has already been completed. Work related to pooling available data for sophisticated epidemiological modelling is in progress.

Computer Science

Algebraic properties of exceptional rules and also of one group of non-exceptional rules for 2D Cellular Automata have been studied. A few results were derived on particular hybrid transformations.

A reliability measure of a computer network was obtained using information theoretic ideas, leading to a dynamic design of a reliable computer network.

Cryptographic properties of boolean functions viz. linearity, correlation-immunity, balancedness etc. were studied. Methods have been developed for construction as well as enumeration of boolean functions which are highly nonlinear and correlation immune of a high order. These methods have been extended to symmetric boolean functions too.

Projects Undertaken

A. Externally Funded Projects

Software Development for Cryptanalysis

Project leader : Bimal Kumar Roy

Cryptanalysis of an LFSR-based cryptosystem has been undertaken. A method has been developed for estimating the seeds of each LFSR and the combining function simultaneously, provided that the length of each LFSR does not exceed 30. This method has been implemented in a parallel environment. Partial solutions have been obtained when the length of the LFSRs exceeds 30.

Development of Statistical Technique as an Aid to Geological Mapping

Project leader : J. K. Ghosh

Project Co-ordinator : Tapas Samanta

A sampling scheme for allocation of optimum number of observation points to most appropriate locations was developed. This settled the question of how many points to sample and where to sample. The final technical report (FTR) has been submitted to the CSIR.

UGC Refresher Course in Statistics at the post-graduate level Organised by the Applied Statistics Unit (February 2-26, 1999)

Coordinators : D. Sengupta and K. S. Vijayan

A UGC refresher course for post-graduate teachers of statistics was conducted by the Unit during February 2-26, 1999. A total of 97 applications were received. These applications were scrutinised by the teachers and 38 candidates were selected. Of these 27 joined (23 outstation + 4 local). Except one, all resource persons were from ISI. Apart from the usual materials covered during lectures, an attempt was made to familiarise participants with statistical packages in common use. Teachers were able to provide lecture notes in advance and these were compiled into a single volume and handed over to participants at the beginning of the course.

B. Plan Projects

Application of 2D Cellular Automata

Project Leader : Pabitra Pal Chaudhury

Studies of various mathematical properties of nearest neighbourhood 2D CA transformations are continuing. These were divided into various groups. The study of two groups concerning only two and three neighbours is near completion.

Some exceptional transformations were identified, which do not match with others and thereby do not fall in any of the above groups. Their properties are being studied separately. Further, a class of hybrid transformations has been identified and their properties are being studied.

Small Area Estimation of Population for the Districts of Hugli and Murshidabad

Project leader : Parimal Mukhopadhyay

The survey project for estimaition of socio-economic characteristics of households in the municipal areas of Mursidabad and Hugli districts is continuing. Data have been collected from about 1100 households from the district of Hugli and about 350 households from the district of Murshidabad. A series of estimates for 10 sampled municipal areas of the Hugli district have been obtained using synthetic estimation techniques and Bayes procedures. Analysis of data from Murshidabad district is in progress.

Optical Character Recognition (OCR) of Printed Telugu Script

Project leader : C. H. Sastry

Selected Telugu text samples were digitized. Programmes for scanning the text image and determining a threshold level in order to convert the image to a 2-tone image have been developed, the objective being the segmentation of the text image for lines and words. Studies are on to set up logical criteria to segment the characters. Many schemes are under consideration and experimentation. The problem of tilt correction is also being studied. Efforts are on to set up the infrastructural facilities required for the project.

Telugu Language Processing

Project leader : C. H. Sastry

From the point of view of designing an OCR system for printed Telugu script, efforts are on to study the statistical characteristics of Telugu language, which is in common written use. For this prupose passages are being collected from popular Telugu magazines, news papers and children's literature. This is required for the purpose of collecting Telugu words used in different expressions of thoughts. Efforts are on to acquire facilities needed to store the passages in computer medium for later statistical analysis.

Analysis of Incomplete Life Time Data

Project leader : Anup Dewanji

A nonparametric estimator of cause specific hazard rates in competing risks with missing failure types has been developed. Robust and nonparametric estimators of a number of component processes in a system of superimposed iid renewal processes have also been obtained. Work on other types of incomplete data is in progress.

A Statistical Projection of HIV Incidence in Calcutta

Project leader : Ayanendranath Basu

As a follow up of the statistical projection for the city of Calcutta completed in 1998, a sensitivity study, and the application of a bootstrap resampling technique to provide standard errors and confidence bands to the projected numbers is now complete. The sensitivity analysis gives a guideline to policy planners in determining which factors should be targeted with higher priority for useful intervention. In addition, a bootstrap resampling technique has been used to provide both standard errors and confidence bands to the projected numbers over the years.

School on Small Area Estimation

Project leader : Arijit Chaudhuri and Arun Kumar Adhikary

This ISI-funded school was organised to disseminate some of the ideas developed in ASU, ISI concerning this topic among people in the country interested in doing theoretical and applied research in this area. A countrywide announcement was sent to various Universities, Departments of Statistics and other recognized institutions doing sample surveys to nominate participants in this school. The school, held during February 8-16, 1998, had 14 selected participants, including those from the Government of India, MSRI, RBI, ITPS and some universities. Eight ISI faculty members participated in teaching. The stress was on applications covering case studies relating to Indian and foreign exercises relevant to this context. Typed course materials were distributed among the participants before the start of the school.

Computer and Communication Sciences Division

The Division comprises Computer Vision and Pattern Recognition Unit, Advanced Computing and Microelectronics Unit, Electronics and Communication Sciences Unit and Machine Intelligence Unit. Faculty members of the Division are also engaged in teaching and training M. Stat., M. Tech. (CS) and M. Tech. (QROR) programs, in addition to their research and project works. Many undergrduate and postgraduate engineering students of Computer Sciences, Electronics and Telecommunication, Electrical Engineering and students of MCA courses from different universities and institutes undergo their vocational/semestral training under the supervisions of the faculty members of this division. Research work carried out in these units is described below.

Advanced Computing and Microelectronics Unit

During the period 1998-99, the faculty members of the Unit were engaged in research in various fields of Computer Science and Engineering. The fields include Heterogeneous Computing, Logic Synthesis and Design for Testability, Multi-Mesh Architecture, Electronic Design Automation, Applications of Computational Geometry to VLSI Lay out, Mobile Computing, Microelectronic System Design using FPGA's, and Discrete Event Simulation.

Research Activities

Heterogeneous Computing

During recent years, Heterogeneous Computing (HC) has become one of the thrust areas of research in the field of parallel processing. HC involves the use of different types of parallel processors, processing components or connectivity paradigms to maximize overall system performance, cost effectiveness and development efforts.

The goal of heterogeneous computing is to achieve fast execution of a complex task on a cluster of high performance systems with possibly dissimilar architectures. It is an important and emerging field drawing concepts from both parallel and distributed computing. Though the different components of HC have appeared in the scientific literature over the past few years, heterogeneous computing is still in its infancy. Heterogeneous computers promise cost effective compute cycles. But there are lot of issues yet to be studied in terms of efficient scheduling, ease of program development, performance evaluation and design of optimal HC environment for a specific application. Scientists and researchers from a variety of disciplines have started participating in the development of heterogeneous applications using a currently available tool named Parallel Vitual Machines (PVM) and the associated job dispatchers.

A suitable model for computation in a heterogeneous computing environment involving a combination of dissimilar machines is being developed. Several theoretical results have been obtained on the efficient topology for interconnecting multiprocessor systems and also on designing parallel algorithms for solving different numerical and graph-theoretic problems, forecasting etc. It is expected that performance evaluation of different application problems mapped on an HC environment containing several (5-6) processing nodes having different architectures would lead to optimization of the computing environment.

Logic Synthesis and Design for Testability

Logic synthesis and design for testability techniques are indispensable in the VLSI circuit synthesis and testing. A typical VLSI chip may consist of hundreds of millions of transistors, design of which requires specialized design tools. To ensure high reliability, yield and maintainability, these chips must be tested during design, production, and while under operation. Unless the chips are designed with in-built easy testability scheme, testing will be a formidable task, if not impossible. The objective is to innovate new design methodology for gate-level logic synthesis and redundancy elimination, targeted to having high fault coverage, in terms of stuck-at faults, as well as robustly testable delay faults.

Logic synthesis with non-scan sequential circuits is of utmost importance in the recent trends of high performance circuit design. Investigations have been done on the redundancy problem in synchronous sequential circuits. Identification and elimination of redundancy have been studied, with a special emphasis on isomorph-redundancy. Several new attributes of such redundancies have been formulated, and their impact on logic synthesis has been studied.

We have also developed a novel scheme of BIST (built-in Self Test) technique for detecting stuck-open faults in combinational CMOS VLSI circuits. Efficient BIST design for universal testing of stuck-open faults was an open problem. The proposed scheme is not only robust but also universal. Its hardware overhead is low, and testing time is significantly reduced. In addtion, a new technique called adaptive BIST has been developed. The scheme is useful for testing arbitrary CMOS complex cells, and the test sequence is independent of the circuit structure and its functionality.

Multi-Mesh Architecture

The Multi-Mesh (MM) architecture, built around 2-D meshes, has newly been proposed by us (Das and Sinha, Proc. 9th IPPS, pp. 17-21, April 25-28, 1995, Santa Barbara, and M. De, D. Das, M. Ghosh and B. P. Sinha, Proc. HiPC'95 pp. 707-712, 1995). This architecture provides the following features:

(a) The number of processors is $N=n^4$, for some integer $n > 2$. The smallest systems can be built with 81 processors.

(b) Every processor will have a uniform degree of 4 only.

(c) Although the number of links is same as that of an illiac IV architecture or a 2-D torus, the MM topology provides a diameter of 2n, i.e., $2N^{1/4}$ in contrast to $2N^{1/2}$ for an Illiac IV topology. This reduced diameter helps to implement the following algorithms very efficiently :

Summation/Average/Maximum/Minimum	:	$O(N^{1/4})$ time
Matrix Transpose	:	$O(N^{1/4})$ time
p x p matrix multiplication	:	$O(p^{0.4})$ time (compare this with O(p) time on a 2-D mesh)
P-point DFT computation	:	$O(p^{0.4})$ time
Sorting		
n^2 independent sets of n^2 elements each	:	$O(n)$ time
n independent sets of n^3 elements each	:	$O(n)$ time
n^4 elements		$O(n)$ time
Lagranges interpolation on n^2 elements	:	$O(n)$ time

(d) The 2-D mesh can also be emulated on this MM topology in constant time. Thus, the 4-neighbour adjacency property can also be preserved in a certain sense on this topology.

(e) Point-to-Point communication, single node broadcast and multicast can all be implemented on this network in $O(n) = O(N^{1/4})$ time.

(f) Under single node or link failure, the diameter will not increase by more than 6. Other properties will gracefully degrade with faults.

(g) Any existing algorithm on a 2-D mesh or torus can be easily transported to this new architecture and this is still a subject of further study and software development.

Apparently, the proposed architecture will be able to efficiently implement a large class of algorithms in numerical applications, image processing and other real-life situations very efficiently without any additional hardware investment over that required for a 2-D mesh.

Efficient algorithms for (i) multicast in $O(N)$ time, (ii) complete exchange using wormhole routing in $O(N^{4/5}\log N)$ time and also (iii) permutation routing on the Multi-Mesh have been developed. The sorting algorithm on the Multi-Mesh has been further improved. During the year in question, a new technique for parallel multi-way merge sort has been developed which has been implemented on the Multi-Mesh with an improved executive time for sorting.

Electronic Design Automation

During the past 10 years, members of this Unit had done extensive research in the area of VLSI Design including synthesis, testing and physical design. New techniques of testable design, partitioning, floorplanning and routing in microchips have been developed. With the advent of high-performance VLSI and ULSI (Ultra Large-Scale Integration) chips, and MCM's (Multi-Chip Modules), efficient EDA tools targeted to achieve high speed and low power design are now in great demand. The research areas explored include (a) Performance driven logic partitioning and floorplanning, (b) Unified scheme for global and local routing, (c) Low power design of VLSI chips.

Efficient algorithms for high performance floorplan design and routing in VLSI Circuits have been proposed and tested on benchmarks. The results outperform earlier methods both in cost of chip fabrication and turnaround time. In particular, we have addressed (i) the optimal linear placement problem of circuit graph to minimize signal delay, (ii) floorplan-area optimization for custom microchips, and (iii) partitioning for improved wire routing based on geometric measures.

Applications of Computational Geometry to VLSI Layout

The physical design phase of VLSI (Very Large Scale Integration) curcuits involves many problems on partitioning, placement, floorplanning, wire routing and area compaction. Furthermore, variations of layout style, technology, and packaging, e.g., FPGA's (Field Programmable Gate Arrays), and MCM's (Multi Chip Modules), lead to numerous design and optimization problems, the formulation of which needs graph theory and combinatorial optimization. In this project, our objective is to identify various VLSI design problems which can by virtue of their inherent power and novelty of spatial data structures and search methods, outperform or augment the conventional EDA (Electronic Design Automation) tools. In addition, these techniques will have manifold applications to defense, robotics, database, and pattern recognition.

We have identified many new design problems that arise in VLSI physical design automation and mapped them to computational geometric problems. New algorithms for maximum-empty region recognition among isothetic/non-isothetic obstacles have been proposed. The algorithms also include recognition of max-width/area empty staircase channels, 3D cuboids etc. We also introduced the *shooter location problem* and proposed efficient algorithms for solving it. A novel routing-driven partitioning scheme has been formulated.

Mobile Computing

Mobile computing refers to the use of portable computers interconnected through wireless networking. It allows the mobile users to effect versatile communication with other people along with continuous access to the services and resources of the land-based computer network. Designing software for a mobile computing system is different from that involved in case of a stationary networked system in certain aspects, as mobility induces several new problems.

Wireless communication used for mobile computing system is characterized by low bandwidth channels with high error rates and more frequent disconnections. These factors can increase the communication latency resulting from the requirement of retransmission of data packets arising due to error control protocol and short temporary disconnections. Mobility, in turn, causes wireless connections to be sometimes lost or degraded due to signal weakening, when the users travel beyond the coverage of network transceivers or enter areas of high interference. Also, the number of devices in a network cell varies dynamically and a large concentration of mobile users at a single place like conventions, may also overload the network capacity.

A mobile computer's net-address changes dynamically. This dynamic feature in mobile wireless networks leads to a problem of keeping track of the topology connectivity. This problem, also known as the location

management problem, becomes too complex when the rate of change is high and the network size is large. Thus, an important issue in mobile computation is the design and analysis of the topology management scheme.

New routing schemes are also needed for such mobile networks. Conventional routing protocols are not applicable for networks where the topology connectivity is subject to frequent unpredictable changes. A suitable loop-free routing is desirable for this purpose, since a loop-free routing will minimize the consumption of resources during communication and also the communication delay involved in the process. Routing schemes also need to be developed to tolerate corrupt wireless links.

In a mobile computing environment, all neighboring base stations are connected to a Mobile Switching Centre or MSC. When a mobile user is about to leave a cell, the cell's base station transfers the ownership of the cell to another base station getting the strongest signal from the mobile user. If a call was in progress at this point of time, then this call should be switched to a new channel (as the old one is not used in any adjacent cell). This new channel assignment is basically done through a switching network.

We have developed a generalized shuffle exchange network, which can be used as an efficient MSC, even when the number of base stations is not necessarily a power of 2. The network offers a very cost-effective as well as fast switching technique for *hand-off* procedure between base stations. The routing algorithm and the fault-tolerance of these networks are currently under study. We have also proposed an efficient location updation technique for mesh topology. Further, a near-optimal algorithm for channel assignment in a mobile computing environment has also been developed.

Microelectronic System Design using FPGA's

Field-Programmable-Gate-Arrays (FPGA's) are now being extensively used to synthesize complex logic circuits in the laboratory. These IC chips have following features : (i) high degree of complexity (thousands of gates) and (ii) complete programmability to implement arbitrary architectures in a laboratory.

Optimal logic synthesis and routing targeted for FPGA realization has become an upcoming area of research. In particular, we shall undertake the investigation on logic-partitioning problem in a FPGA environment. Given a complex circuit in terms of interconnection of modules, the problem is to partition it into smaller sub-complexes, such that the overall design and routing on FPGA become optimized.

Synthesis of fault-tolerant systolic arrays with FPGA architectures is being studied. We have also developed a new technique for synthesis of large synchronous sequential machine. The proposed design has less hardware overhead, shorter test application time, and a very high fault coverage. The design can easily be mapped to a FPGA-based architecture.

Discrete Event Simulation

Synthesis of very large sequential machine now forms an integral part of high performance ASIC VLSI chips. Typically, such circuit might consist of 30,000 logic gates or more.. The circuit is described in VHDL environment, then steps of partitioning, finite-state machine synthesis, and final logic design need to be performed.

To check the correctness of the design, it is required to have an extensive simulation study. This involves: (i) logic simulation, (ii) fault simulation, (iii) timing simulation, (iv) layout simulation.

If any design error is identified during simulation, it is corrected and the process is iterated. Discrete event simulation is also indispensable in evaluating the performance of a parallel processing system. In our array processor-based system, performance of various computer networks and parallel algorithms are being studied. Study of such designs will also require discrete event simulation in a large scale. Typical examples are job queuing, deadlock, broadcast, message routing protocol etc.

Various studies on the development of efficient methodologies for discrete event simulations have been carried out. A Parallel Virtual Machine (PVM) environment is also being studied in a UNIX environment run on a Silicon Graphics Workstation. Logic simulation at switch-level is being studied on a PC platform.

Large scale simulation studies have been made in the earlier years to assess the performance of a (64 x 64) baseline switching network with output buffering. It has been observed that the output buffering scheme provides more throughput and manages traffic quite efficiently. The traffic rate was varied from 20 % to 100 % whereas, the number of buffers in a queue within a switch was varied from 1 to 12.

Computer Vision and Pattern Recognition Unit

Research Activities

Mathematical Morphology, Dot Pattern and Cluster Analysis

An efficient approach based on mathematical morphology has been developed to detect circular objects in a sense. Further, mathematical morphology has been extended to detect shape of dot patterns.

The task of shape identification of dot patterns has been considered. A new shape definition called S-shape has been proposed. It has been refined to r-shape which can be computed in linear time while other existing techniques take $O(N\log N)$ time. Generalization of the dot pattern shape identification has been made to take care of patterns with variable density and having line-like extensions.

An improved multi-seed data clustering algorithm has been proposed. It has been demonstrated that the algorithm works quite efficiently. Detection of clusters within a cluster has been worked out. The problem of clustering of noisy and imprecise data is also studied. The problem has been considered in the context of k-means clustering algorithm.

Computational Linguistics, NLP & Speech Analysis

From a large corpus, statistical analyses of the Bangla text is continued. Statistical analyses of phonemic representation of the data has been done. Morphological analysis of Bangla words has been started from the linguistic point of view. This includes preparation of suffix list, categorization of compound words; reduplicated and echo-words, pronominal and other ambiguity categorization, etc.

Work on Bangla verb analysis has been continued and morphological parsing of compound verbs, has been implemented. Now work on non-verb words has been initiated. A spell checker prototype has been designed for non-word error detection in Bangla text. A correction strategy has been formulated. It is being extended to take care of some real world error detection. Computer implementation grapheme to phoneme conversion rule has been worked out. Work is in progress to produce speech mode output of OCR and spell checker already developed. The work will be useful for the visually handicapped. Work has been started on limited domain automatic translation between Bangla and Hindi languages. The domain chosen for the purpose is the weather and calamity forecasting. In collaboration with International School of Dravidian Linguistics, Kerala, a study has been started on automatic synthesis of Malayalam speech sound.

Optical Character Recognition and Document Processing

An improvement, in respect of style and size variations, has been made on the existing Optical Character Recognition (OCR) system of printed Bangla script. A robust technique for automatic skew-detection and correction for the Bangla and Devnagari text has also been developed. Some statistics have been computed for Hindi language for OCR development on Devnagari script. A bilingual printed OCR system has been developed to read two most popular Indian scripts (Bangla and Devnagari). Since India is a multi-lingual country, it is important to develop a multi-lingual OCR system. To start with, a system has been developed for automatic separation of Bangla, Hindi and English scripts in a document. Preliminary study has been started on South Indian Language OCR systems like that of Telugu and Tamil.

A document page may contain different types words like bold, italics, all-capital etc. An automatic, simple and fast method has been developed to detect these different types of words. The information can help to enhance the recognition accuracy of the existing OCR system as well as to extract important information from

document which are printed in uppercase of bold and italic styles. Work on hand printed Bangla character recognition has been initiated.

3D Digital Geometry and Biomedical Image Processing

An automatic cell segmentation algorithm has been developed. Different edge based techniques for segmentation of 3-D Confocal Images are implemented and compared. Snake algorithms are suitably modified for tracking the complete 3-D surface of the selected cells. Deformable model algorithms have been designed and implemented for the segment of the cells of interest in volumetric tissue specimen images. Region based algorithms such as seeded volume growing and 3-D watershed algorithms are improved and implemented for segmentation of histo-pathological images obtained using complete microscope. FISH signal detection and counting has been automatized. Algorithm for different cytio and histological feature detection and measurement for cancer grading are developed and implemented. Automatic cancer grading system based on 3-D histological images is being developed. Algorithms are developed and implemented for quantitative evaluation of the filamentous bacterias in industrial sludge based on 3-D images. Work on development of medical image database management is in progress.

Neural Networks

An adaptive method has been developed to update, in an autonomous way, the learning rate of the back propagation algorithm for a multilayer perception. In this context a new concept, namely, the effective value function of the learning rate, has been defined. The new adaptive algorithm has been found to be useful in some real life problems and has produced much better performance in terms of convergence speed than the original back propagation algorithm. The applications considered are (a) texture segmentation problem which does not consider a feature set and (b) classification of remote sensing imagery. Further, the robustness of the proposed algorithm is being studied.

A modification of the self-organizing neural network model of Kohonen has been proposed. A dynamic version of the network has been developed where the size of the network can grow or reduce during the learning process depending on the data. The dynamic network has been applied for efficient shape representation and a unified approach to skeletonization of 2-D patterns (binary or gray level images or dot patterns) is proposed. The robustness of the proposed shape representation algorithm in comparison to the existing algorithms for the same purpose, has been established. Certain modifications have been made so that even the local topology of the network gets adapted (unlike in Kohnen's feature map) on the basis of the input.

Work is being continued to explore how a redundant multilayer network behaves under component failure during training and operational phase of the network.

Electronics and Communication Sciences Unit

Research Activities

The major research activities in the year 1998-99 include the following areas : Theoretical and Experimental Investigations in Computer Vision, Biomedical Imaging and Image Analysis, Artificial Intelligence, Approximate Reasoning and Neuro-Fuzzy Computing, Remote Sensing and Data Analysis in Atmospheric Science and Wave Propagation, Acoustic Phonetic Studies on Indian Speech and Musical Sounds Leading to Automated Speech Recognition.

The highlights of major research works conducted during the year 1998-99 are as follows.

Mathematical Morphology

Use of mathematical morphological tools is investigated. A multiscale morphologic edge detector is proposed. Results of proposed method are compared with those of conventional methods, and they are found superior. The proposed technique is also computationally less expensive. One dimensional pattern spectrum, also

known as size distribution, is extended to two-dimension. As a result, the notion of shape-size distribution is better represented by the proposed bivariate pattern spectrum. The properties of bivariate pattern spectrum are also studied.

Document Image Analysis

Algorithms for document image segmentation are developed. The algorithms are tested on a large number of benchmark images available at document image database UW-II. The proposed algorithms decompose a document image into its constitutents : text, graphics, half-tone, table etc. A model based strategy for evaluating the performance of segmentation algorithm is also proposed. Work on vectorization of engineering drawing is also in progress. A new method for extraction of straight lines from drawings is developed. Extraction and parametrization of circle and circulars are being investigated.

Multisource data Integration

Work on integration of multisource data is in progress. A new concept called morphological tower is employed to fuse or integrate MR and CT images to bring together information collected through different modalities. The technique is being applied in satellite images too. The concept of morphological tower is used to develop an algorithm for local contrast enhancement for biomedical images.

Pattern Recognition

A new method for direct generation of fuzzy rules from numerical data for classifier design has been developed. Given any test data point, most classifiers including neural ones, classify it in one of the classes, wrong or right ; but the proposed classifier can declare ambiguous points (ambiguous with respect to the training data) as "unable to classify'. This is unique feature. Moreover, it can deal with fuzzy test data. A scheme for fuzzy rule generation from RID3, an ID3-type decision tree algorithm for real data, has been proposed.

Fuzzy Control

Some model-independent self-tuning schemes for PI and PD type fuzzy controllers have been developed which attempt to mimic expert operator's control strategy. Strategies for rule extraction/reduction for such self tuning controllers have also been developed. A novel scheme for fuzzy rule based system identification has been developed and applied for designing self-tuning controllers. A few schemes for similarity based approximate reasoning have been proposed and applied to classifier and controller design.

Neural/Neuro-fuzzy and their computation

A fusion methodology (between fuzzy logic and neural net) has been developed and tested for recognition of vowels and occluded object.

Several neural methods for feature selection and ranking have been developed. Two connectionist schemes for structure preserving dimensionality reduction have been developed. A few fuzzy rule based structure preserving dimensionality schemes have been proposed. (It is possibly the first attempt of this kind.) These schemes produce excellent results and have predictability. In this regard, currently we are integrating fuzzy logic with self-organizing feature map. Several variants of self-organizing feature maps (SOFM) have been developed with more biological plausibility, low computational cost and easy hardware realization. SOFM is also used to extract a small set of prototypes for designing nearest neighbor classifier. The algorithm dynamically modifies the network by adding/deleting/modifying prototypes to enhance performance of the classifier.

Various connectionist models for fuzzy reasoning have been developed which exploit the benefits of both neural networks and fuzzy logic and eliminate some of the serious limitations of either paradigm. In this regard, a neural realization of compositional rule of inference with greater flexibility is developed.

Qualitative Physics and Computational Material Sciences

An extension of the qualitative simulation (QSIM) algorithm has been made with qualitative curvature. The basic purpose of qualitative physics is to describe the behavior of the complex dynamical system in a qualitative manner instead of quantitative differential equation.

Soft computing tools have been successfully used to characterize the hydrogenation and de-hydrogenation characteristics of hydrogen storage composite materials. This can result in a drastic reduction in time, cost and research effort to characterize new composite materials without doing the actual experiment.

Analysis of Satellite Data

The objective of developing a comprehensive algorithm for the classification of the convective clouds is (a) to track cloud clusters in a sequence of INSAT satellite images routinely performed by the Indian Meteorological Department (IMD), Alipore and (b) to provide cloud motion vectors (CMV). Determination of the CMV is based on correlation technique as well as classification technique applied to the half-hourly INSAT image triplet. These clouds provide betterment in terms of quantity and quality of the CMVs. The work on study/classification of convective clouds based on temperature profiling of satellite (IR-band) imageries has been reputed (under review) in a journal. Currently effort is being made on extraction of cloud contours (satellite images) by Active Centours method (one of the most recent I.P. methods). Neural Network Approach is also attempted for further improvement of the result.

Analysis of SODAR Images

Patterns of ABL (Atomospheric Boundary Layer) shapes have been extracted from SODAR images. A rule based algorithm for network driven inferencing mechanism has been developed and successfully tested on recognition of SODAR patterns. An algorithm for image segmentation based on Fuzzy c-means has been implemented for SODAR image. Recognition and inter-pretation of ABL SODAR pattern has been published in International Journals.

Modeling of transport phenomena in ABL

A model has been suggested for inertial transfer of turbulent energy in homogeneous and isotropic turbulence. In homogeneous and isotropic turbulence, a third order structure function may be expressed with the help of third order moments of various categories. But on the basis of the argument that the inertial transfer range eddies are self-similar and the structure function would follow a power law, spectral representation of transfer term (following Navier's - Stoke's equation) has been modeled in terms of the power of eddy size. Solution of these equations will provide several interesting results as reported and communicated to journal.

A work has been taken up to understand the underlying relation among the embedding dimension, the dimension of the attractor and the dynamics of a system. It is investigated how the embedding dimension of an atmospheric system may be calculated using different methods including the method of false nearest neighborhood. An attempt would be made to investigate with atmospheric data as to how the dimension of the attractor and the embedding dimension may be used to understand the internal mechanism of the dynamical system. A preliminary paper was read in an International Symposium.

Fractal algorithm for the study of ABL dynamics

An attempt has been made to characterise turbulent convection in the surface layer caused by plumes. Fractal and multifractal dimensions have ben used for the purpose. Following the well-known Kolmogorov's hypothesis, it is argued that since eddies in the inertial transfer range are self-similar, the average rate of dissipation if calculated over the area of the size of the inertial transfer eddy would form fractal set. The average of the rate of dissipation in that block has been calculated. By the term 'block' is meant the area of locality so selected that it is in the same order as that of the size of the inertial subrange eddy.

In the present work, one multifractal dimension i.e., correlation dimension has been calculated and it has been observed that where intermittency is visually located, deviation of correlation dimension from fractal

dimension is large. In addition to the study of a sodogram with the help of fractal and multifractal dimension the study may render some interpretation of multifractal dimension. A paper has been published on the work (JASI'98). A detailed study has been taken up for implementing the findings of fractal and multifractal dimension of wind directions so as to understand different microclimate. Multifractal dimensions may have their own interpretation and are expected to produce interesting results of far reaching consequences on the basis of which a preliminary paper is communicated to an international seminar.

Acoustic Phonetic Study

Acoustic phonetic studies of Assamese fricative consonants have been investigated. Spectrographic analysis of 330 Oriya words spoken by four educated male informants are carried out to study the acoustic phonetic features of this language. The elaborate study on acoustic phonetic features of Oriya vowels has been reported. All these studies will provide reliable acoustic phonetic data needed for computer recognition and synthesis of speech for these languages. This research work also provides assistance to the effort in standardisation of phonetic quality for educational and cultural use of voice media.

Perception study

Acoustical correlates of perceptual stress pattern in Bengali text reading is examined and reported. The result indicates that Bengali is a language with bound stress, the stress being at the first syllable. Furthermore, the acoustic data supports the augmented articulatory effort theory for stress production. In another work the patterns of various semental duration in normally spoken continuous Bengali speech are investigated. The test bed consists of a 5 minute long radio broadcast by a male news reader of All India Radio, Calcutta center. The observation shows some unexpected behavior of the segmental durations particularly with respect to wordlength, position in words and sentences as well as relation to breath pauses. Extreme low values of syllable and vowel durations have been observed. All these studies are necessary to develop a comprehensive knowledge base for automatic computer processing of speech.

Neuro-fuzzy speech recognition

Neuro-fuzzy system has been developed for recognition of Bengali and Assamese vowels. About 80 % recognition score is achieved by this method. An attempt will be made for speaker independent word.

Musical gharana identification

In Indian classical music different shruti positions have been extracted from records of actual performances of several masters on raga iman. The analysis of shruti positions are necessary for identification of different gharanas. The shruti positions have also to be extracted for other important ragas of Indian classical music. The relation between shruti positions and gharanas has to be established for identification of gharanas.

Machine Intelligence Unit

The Machine Intelligence Unit (MIU) carries out basic research concerning certain aspects of machine intelligence. Machine intelligence conveys the core concept of pattern recognition and machine learning with the advanced technologies like fuzzy logic, artificial neural networks, genetic algorithms, fractal, wavelets and rough sets.

The investigation that is currently being done in MIU comprises both the development of these technologies individually and in an integrated (hybridization) manner, and demonstrating their effectiveness in solving various problems of pattern recognition, image processing, brain modeling, expert system, vision, control etc. related to the design of intelligent systems. Hybridization such as neuro-fuzzy, neuro-rough, neuro-fuzzy-genetic helps in making such systems artificially more intelligent. These tools are collectively known as soft computing paradigm. They provide the theory of flexible information processing, which can deal with real life ambiguous situations in an efficient manner like human beings, and therefore form the basis of future generation computing systems.

Research Activities

Pattern Recognition

Genetic algorithms with a fixed number of hyperplanes is used for modeling the decision boundaries for pattern classification. It has been proved that as the size of the training data tends to infinity, the error rate of the GA based classifier approaches the error probability of Bayes classifier. The number of hyperplanes required for modeling the class boundaries has been automatically evolved utilizing the concept of variable string length. Its merit over other strategies like simulated annealing, linear discriminant functions and learning automata in classifying patterns in R^N has been studied. The utility of the system in classifying the pixels of SPOT images has also been demonstrated among other real life applications. Similar other investigations include identification of ill-defined man-made objects such as airports, seaports, roadmaps, beaches, etc., using a multivalued recognition system developed earlier. A software package developed on this has been handed over to defence personnel for their use. An analogy of the GA classification with MLP is determined. Based on this, an algorithm for optimum network generation is formulated.

A modification in k-means algorithm is suggested for reducing the computing time. A minimal spanning tree based criterion for finding α for the construction of α -hull has been found. A concept of *fuzzy* α-*hull* is also proposed. A new minimal spanning tree based clustering algorithm has been proposed and its relationship with Bayes classifier has been theoretically found.

Some important real life applications of neuro-fuzzy approaches include EEG and Fingerprint classification. Fuzzy geometrical features are used for classifying distorted overlapping fingerprints directly from raw images. An intelligent decision making system for obstacle avoidance by a mobile robot has been developed. The task of incorporating audio and visual capability is in progress.

Image Analysis/Processing and Computer Vision

The multi resolution aspect of wavelet analysis is used to authenticate the edge locations. A new method of edge detection using the concept of multi resolution and mathematical morphology is developed. The new method is found to have better noise immunity and positional accuracy compared to other existing morphological techniques.

Algorithms have been developed for compression of images based on Hilbert as well as raster scan. Hilbert scan produces better compression ratio than raster scan. For achieving good compression ratio, different wavelets are now under investigation. An attempt is being made to segment an image using weighted entropy measures depending on spatial distribution of gray levels.

A new gray scale based Hough transform algorithm has been proposed for finding line segments. This is useful in extracting gray regions, especially for satellite images.

Artificial Neural Networks

A connectionist model for learning Hough transform has been developed which provides an efficient representation of the visual information. Connectionist models (X-tron and PsyCOP) for formation of category codes from mixture of patterns had been developed which are employed for structured object recognition and peak detection in parametric space.

Algorithms for optimal feature set selection for pattern recognition problems and for automatic selection of an optimal/near optimal architecture for an MLP have been developed. An MLP based approach for determining the shape of a pattern class from its sampled points is proposed.

A knowledge-based connectionist system incorporating domain knowledge has been developed for classification and rule generation. The system helps in speeding up the net other than improving performance. Negative rules can also be extracted.

A new learning algorithm is designed for blind separation of uniformly distributed source signals. For uniformly distributed sources the Fisher information matrix diverges, and under such circumstances the Cramer-Rao bound is not applicable. It is possible to design new algorithms for such special cases which exhibit superefficiency of $O(1/T^2)$ convergence. The design of the new learning algorithm is an attempt in that direction.

An application of neural nets has been made in the areas of materials to make it more productive and useful at much lower cost, effort and time.

Genetic Algorithms (GA)

Here the investigation involves both theoretical development of GAs and its different applications to pattern recognition and image processing problems. Convergence of GAs with elitism is proved. Pessimistic and optimistic stopping times for GAs (with elitist model) have been obtained. Attempts are being made to find average ϵ -optimal stopping times for GAs.

The effect of emulating sexual discrimination in artificial genetic algorithms is studied. The results show a marked improvement over the conventional or asexual genetic algorithm. The schema theorem is shown to hold for the modified methodology. It is established that in most situations the lower bound of the number of schemata sampled by the modified method is better than its conventional counterpart. The effect of chromosome differentiation for performing restricted cross-over operation is studied. This helps in accelerating convergence of the GA process.

A new crossover technique called "self-crossover", which retains the stochastic and evolutionary characteristics of genetic algorithms, has been proposed. This new operator serves the combined role of crossover and mutation. It has been proved that self-crossover can generate any permutation of a given string. Its utility has been demonstrated for feature selection problem and Traveling Salesman Problem.

A concept of "age of individuals" so as to decide the 'parenthood' of them is introduced; this is seen to maintain more diversity in the population. Middle aged individuals are considered to be more fit to produce offspring. In another work, parents' fitness is used as a part to decide the fitness of individuals thereby giving more importance to individuals coming from 'better families'. This gives more directionality towards the goal. A few strategies are developed to select mating pairs for the crossover operation. A study on the utility of the multi-parent crossover (in contrast to two parent crossover) is also made.

A concept of search space division by employing a multi population scheme is introduced. Here a GA divides the whole search space into sub spaces depending on the convergence status of the population and the solutions obtained so far. The scheme helps to prevent premature convergence to local optima for multi-modal problems.

A methodology for searching robust solutions (in contrast to the best one) by GAs is developed. The scheme employs addition of noise with the search space parameters, before evaluating the fitness of individuals. This scheme helps in real life design problems where solutions are expected to be unaltered with small variation of parameters.

A GA based model to evolve Hopfield type optimum network architectures for object extraction has been developed using fuzziness measures. The performance of GAs vis-a-vis simulated annealing for optimization is investigated.

A method has been developed for fitting straight lines to data sets using GAs. Its superiority over the spline based methods is established. The problem of outliers has been tackled effectively.

Fractals and Wavelets

A method has been developed for magnifying digital images using fractal codes. These codes are generated using GAs that reduce the memory requirements and computing time. A mathematical analysis of the reconstructed images using IFS codes has been carried out. This GA based compression scheme has been

successfully extended to color images. An edge extraction algorithm for images in the process of fractal reconstruction has been developed. Attempts are being made to develop an online photocopying algorithm for image compression.

Wavelet analysis provides multi resolution representation of signals which leads to a fast wavelet transform. Wavelet frame gives an over complete representation of the signal and it is translation invariant. An efficient and robust scheme is being developed for reliable feature extraction with special emphasis to rotation invariance, using multiresolution wavelet frame analysis of the textured images.

Neuro-Fuzzy Computing

Concept of fuzzy sets has been incorporated at various stages (e.g., input, output, learning and neuronal level) of Kohonen's network and multi-layered perceptron to handle imprecise, incomplete or linguistic input data and intractable pattern classes for recognition. Its extension to expert system for rule generation and inferencing has been made along with applications to real life data. This shows how pattern description in terms of linguistic properties and membership values can be processed by a neural net for fuzzy and crisp classification. A generalized framework for integration of multilayer perceptron and fuzziness measures has been developed to design an unsupervised system for object extraction. Implementation of fuzzy set theoretic operators using neural networks and the utility of these networks in pattern classification and rule generation have been demonstrated.

Various ways of integrating fuzzy set theory and connectionist systems for feature evaluation under both supervised and unsupervised modes have been formulated together with the theoretical analysis. An attempt is being made for building a case-based pattern recognition system in this framework. Incorporation of fuzzy set theory helps in selecting the {\it cases} from ambiguous/overlapping regions. The network model is determined through growing and pruning of nodes under supervised mode of training.

Brain Modeling

The human brain is a much superior information processing machine compared to any artificial device constructed so far. This has led scientists to study in detail the different processes involved in biological neural computation and to incorporate the facts so gleaned into more realistic models of brain function. This enterprise, known as "brain modeling", aims to create artificial entities, more "intelligent" compared to present-day systems in performing cognitive tasks.

Work has been carried out in networks of excitatory-inhibitory neural pairs with piecewise linear activation function. Even simple networks have been seen to exhibit a complex range of behavior, including super-stable periodic orbits and chaos. Analytical calculations and computer simulations have shown features like border-collision bifurcations and riddled basins of attraction of the system. The investigation also uses sigmoidal activation functions. Motivated by the neural architecture of the retina, three layers of such pairs have been connected via appropriate weights. Edge-detection and segmentation of gray-level images by processing through these layers have been studied.

The phenomenon of state synchronization among elements of a coupled chaotic network has been studied. A system of three chaotic elements was coupled with each other, such that they competed with each other in phase-synchronizing the network. This work is pertinent in discovering the neural basis of "attention".

Stochastic Resonance (SR) is a nonlinear phenomena, where noise plays a constructive role by enhancing subthreshold signals. As the output of deterministic chaotic process is often indistinguishable from noise, a study on whether chaos can give rise to SR-like behavior was carried out. Using a piecewise linear chaotic map, periodic perturbations were given in both multiplicative and additive sense. It is shown that in all cases the response of the system is enhanced at the signal frequency. This points to the utility of chaos in neural networks for amplifying weak stimulus.

Fuzzy Sets, Rough Sets and Applications

A new method for extracting fuzzy if-then rules for pattern classification is developed. The training data is clustered for each class separately using subtractive clustering method or fuzzy c-means. The method accounts

for interaction between data from different classes resulting in a better initial rule-base which is further refined using gradient descent. After hardening, if a cluster primarily consists of points from a particular class, then that cluster was translated into a rule for that class. Otherwise, the cluster is split into more than one subclusters and each subcluster is translated into a rule.

An integration is made between fuzzy sets and rough sets, by providing a measure of roughness of a fuzzy set. Properties of this measure have indicated possible applications for handling uncertainties in the field of pattern recognition and image analysis.

Rough sets are combined with fuzzy neural networks for designing a knowledge-based system. Rough set-theoretic techniques are utilized for extracting crude domain knowledge that is encoded among the connection weights, using dependency factors and reducts. The optimal number of hidden nodes is automatically determined. The classification performance is found to be better than the conventional and fuzzy versions of the MLP.

A way of incorporating genetic algorithms in this framework, for classification and rule generation, has also been devised. The novelty of the method lies in applying rough set theory for extracting dependency rules directly from real-valued attribute table consisting of fuzzy membership values. This helps in preserving all the class representative points in the dependency rules by adaptively applying a threshold that automatically takes care of the shape of membership functions. The GA tunes the fuzzification parameters, and network weight and structure simultaneously by optimizing a single fitness function. This methodology helps in imposing a structure on the weights, which results in a network more suitable for rule generation.

Projects Undertaken

The Institute has an international collaborative project with the College of Engineering, Osaka Prefecture University, Osaka, Japan, which was initiated and is being coordinated by MIU. Members of MIU are also involved as co-investigators in the Indo-Polish collaborative project titled Reasoning under uncertainty about complex objects/rough set theory and fuzzy set theory. This is coordinated by the Dept. of Science and Technology (DST), India and the Polish State Committee for Scientific Research (KBN), Poland. Several other externally and internally funded projets were also carried out during the year 1998-99. These are listed elsewhere.

Physics and Earth Sciences Division

The division comprises Geological Studies Unit and Physics and Applied Mathematics Unit. Faculty members of the division are engaged in teaching and training in B. Stat., M. Tech. (CS) and M. Tech. (QROR), besides their research and project work. Research carried out in these units are described below.

Geological Studies Unit

The Geological Studies Unit is conducting a number of thematically integrated research programmes centered around the Proterozoic geology and Gondwana geology of several basins in peninsular India. Empirical statistical analysis of naturally arising field and laboratory data is an important aspect of research of the Unit. The Unit is also supporting research programmes on Colloid, Surface and Environmental Science.

Research Activities

Proterozoic Geology

Origin of massif-type charnockite of Jenapore, in the northeastern sector of the Eastern Ghats belt, was studied and dehydration melting in mafic rocks has been demonstrated. Petrologic and geochemical studies of the so-called incipient charnockite of Kabbaldurga in Karnataka reaveal older mafic granulites and not the peninsular gneiss as the precursor of the charnockites. Field data suggests an extensional setting for the emplacement of the alkaline complex of Rairakhol, Sambalpur district, and different phases of the alkaline magma have been identified. Granitoid enclaves in the granulites, at the northern margin of the Eastern Ghats belt were dated by Pb-Pb Zircon

and Rb-Sr whole rock methods as ca. 2.8 Ga. A prominent shear zone marks the boundary of the granulite and granite-greenstone of Bastar. Additonally, bimodal volcanics, pyroclastics and hybrid andesitic magmatic rocks are noted in the area.

Two phases of minor folds, the first set represented by overturned to reclined folds and the latter set by upright to inclined folds have been indentified along the eastern margin of the Nallamalai Fold Belt (NFB). The granitoid at the core of the Vellatur domal structure is syn to late tectonic with respect to the latter set of folds. Around Vinukonda and further south, granite-gneisses are overthrust along the eastern margin over the Bairenkonda Quartzite of the NFB. Analysis of structures show that in the western NBF slaty and /or domainal cleavages appeared early in the sequence of development of structures as cleavages are sometimes reoriented in vertical to overturned fold limbs or in steep shear (fault) zones.

In the Sanipai-Balrajupalli section Cuddapah district, a granitoid basement with dyke swarms is non-conformably overlain by a c. 100 m. thick succession dominated by fine to coarse sandstone and some shales. The sediments were derived from the exhumed basement. The overlying sandstone-shale sequence (c. 100 m at Sanipai; the Nagari Quartzites) represents storm influence on shallow shelf deposit. The above facies are persistent over a strike length of over 30 Kms.

The plutons in the Sonakhan Belt of Chattisgarh in Central India and the surrounding granitoids belong to granite and granodiorite fields in Streckeisen's QAP plot. Bulk of the granitoids are syntectonic with respect to deformation in the supracrustals (greenstones). Deformation microstructures in quartz and feldspar suggest superimposition of a subsolidus deformation fabric subparallel with the magmatic fabric in the syn-tectonic granitoids.

The thick sequence of sedimentary rocks in the Sonakhan greenstone belt is bounded both to its east and west by volcanics dominated successions. The pebble lithology indicates that the detritus were primarily derived from a volcanic chain with instrusives of granitoid rocks. The conglomerates and sandstones developed as a series of coalesing dep marine fans, forming an apron.

A fan delta-prodelta and two prograding shelf successions have been identified in the southern part of the eastern Chattisgarh basin. Repeated sea level changes, rifting and uplift along its eastern margin is indicated. A riftogenic origin of the Chattisgarh basin is postulated.

An attempt has been made to delineate the Mesoproterozoic - Neoproterozoic boundary in peninsular India. The kimberlites which intruded the Indian peninsula in widely separated areas around Cuddapah basin, Vindhyan basin and Indravati basin at around 1100 Ma may be considered as a key element in defining the Meso-Neoproterozoic boundary. The boundary may be fixed at 1000 Ma, and it would be compatible with recommendations of the International Subcommission on Stratigraphic Correlation for global chronometric classification of the Proterozoics.

A brief field work in the Dongargarh basin led to the recognition of a thin aeolian deposits. Recognition of aeolian deposits in several disparate basins, i.e. Dongargarh, Sullavai or Vindhyan, indicates special importance of wind activity in Precambrian Earth surface processes. Aeolian deposits are uncommon in rocks older than 1800 Ma. The Dongargarh deposits are prbably more than 2200 Ma old.

Gondwana Geology

Field work on the Lower Gondwana Barakar and overlying Motur Formations has revealed remarkable contrast in the sand body architecture of these two units. A remarkable change in the climate and also in the rate of basin subsidence through time is indicated.

The studies in the Upper Gondwana Denwa and Bagra Formations (early-middle Triassic to early Cretaceous in age) of the Satpura basin were continued. The facies analysis of the Denwa and the Bagra sediments indicates presence of different fluvial systems and sedimentary processes in an alluvial setting. The lower part of the Denwa Formation is devoid of recognizable paleosol profiles, whereas the upper part contains a number of well-developed, mature, calcic paleosol horizons at different stratigraphic levels. Vadose zone pedogenesis under

semi-arid climatic setting is suggested. The $\delta^{13}C$ values of the paleosol carbonates indicate that the partial pressure of CO_2 in the atmosphere was much higher than the present atmospheric concentration of CO_2.

A new faunal assemblage very similar to that of the Moenkopi Formation of U.S.A. has been found from the Denwa Formation. It comprises two new species of *Parotosuchus*, a brachiopod, dicynodonts and rhychosaurs establishing an early Middle Triassic age for the Denwa Formation. The overlying Bagra Formation produced archosaur teeth and vertebrae. This latter finding indicates the presence of another younger faunal assemblage.

A complete review of the Gondwana vertebrates of India has been completed. A synthesis of the available data on the Triassic terrestrial vertebrate biochronology of India has been completed. The sequence of Triassic terrestrial vertebrates is most completely preserved in India than in any other Gondwana province of the world.

Colloid, Surface and Environment Science

Systematic investigations on maximum solubilization of water, oil and other ingredients in microemulsion systems using single and mixed surfactants vis-a-vis their physicochemical studies are in progress. It has been shown that the different phases (monophasic, biphasic, lamellar, liquid crystals etc.) coexist in equilibrium systems. Besides, a large, clear single phase (1ϕ) zone have found in most of the systems indicating a good prospect of solubilizing the additives/ingredients.

Physics and Applied Mathematics Unit

The faculty members of PAMU carry out research in diverse areas of current interest in Theoretical Physics and Applied Mathematics. Most of the Applied Mathematicians of the Unit are engaged in experimental studies as well. Apart from problems of theoretical nature, real life problems are also taken up by the scientists in the Unit. There include collaborative research work with other Units of ISI and with different Institutions in India and abroad.

Apart from research activities in Physics and Applied Mathematics faculty members of this Unit are engaged in teaching various courses like B.Stat (Hons), M.Tech (CS), M.Tech (QROR) and Regular Course of CSC. The Scientists also guide and assist research students (towards the Ph.D degree course) and research associates. Scientist in PAMU also conduct advanced courses to research students.

Research Activities

Theoretical Physics

Data analysis and modelling of blizzards of experimental results emanated from both the natural and laboratory based accelerators and colliders at very high and ultra high energies are of importance in Physics as they help one understand the generalized behaviour of high energy particles and astroparticle collisions. They also throw light on the actual nature of strong interaction dynamics and important particle structures. Recent research in this area boldly attempts to provide some understanding of the 'soft' (non-perturbative) collisions, which constitute roughly 90 per cent of the natural events at high energies.

In the area of Condensed Matter Physics, theoretical understanding of various characteristic features of integral and fractional quantum Hall effect as well as topological aspects of high T_c superconductivity are of current interest. A new unified approach through chiral anomaly and Berry phase formalism has been proposed to study quantum Hall effect.

In the emerging area of Extended Electrodynamics, an extended formulation of Maxwell electrodynamics has been suggested using the concept of sapce-charge in vacuo as well as the existence of conductivity in vacuum. This helps to solve some of the difficulties encountered in conventional Maxwell framework. Non-zero rest mass of photon has been shown to be associated with longitudinal solution, which might play significant role in astrophysics and quantum gravity.

The research in Foundations of Quantum Mechanics concerns the problems of Quantum Entanglement, Unsharp observables, Bell-type correlations and large scale structure of the universe. New experiments have been proposed to detect the unsarpness parameters using molecular detector.

Nonclassical states of the radiation field are of current interest in the area of Quantum Optics, as they have considerable applications in optical communication and precision measurements. A specific realization of the phase space has been suggested in the context of Pegg Barnett quantum phase theory, which plays an important role in Quantum Optics.

Solitary waves and double layers in relativistic multicomponent plasma is the most important area of research in plasma physics. Exact pseudopotential for a relativistic plasma has been derived for the first time.

The study of Q-deformation of quantum mechanics, conservative quantum dynamical semigroup, $\mathcal{PT}$ symmetry in quantum mechanics are the topics of current research in Supersymmetric Quantum Mechanics. A novel way of supersymmetry breaking has been proposed in a paper. A connection between partial algebrization and supersymmetry has been also suggested. A formalism based on WKB, MAF and SWKB methods has been developed for determining energy eigenvalues of confined quantum mechanical systems.

In the area of Theoretical Astrophysics, Wolf's discovery of shift of spectral lines is under investigation in case of cosmological redshift. An important work that had been done was to show that the shift of the spectral lines is larger than the width of the lines contrary to Schrödinger's work. Tully-Fisher relation has been derived recently within the multiple scattering theory, which relates the width of the spectral line and the distance of a quasi-stellar object. A more general relation between the distance and the width is predicted, which may be verified for high redshift quasars.

Pattern-forming Instabilities are about the physical systems driven far from thermodynamic equilibrium, which often show transition from isotropic state to anistropic one varying in space or in time. Selection of various spatio-temporal patterns and other nonlinear phenomena in soft condensed matter are of current interest. The study of granular materials under vertical vibration addresses some basic issues in the area of physics of granular materials.

Applied Mathematics

Integral expansions involving associated Legendre funcions and other special functions are being developed and applied to handle problems on continuum mechanics. A variety of integral equations, dual integral equations, Fredholm integral equations, hypersingular integral equations arising in various areas of mathematical physics and water waves in particular are being studied.

A few models in the area of inventory and queueing have been constructed. The inventory models involving stock-dependent demand have been received wide appreciation in the Operations Research literature.

Fluid Mechanics

Basic fluid flow models for Industrial Fluid Mechanical problems are developed with a view to understand the physical processes involved in their industrial applications. On thin film development research, it has been observed that it is possible to obtain an ultra thin film of desired thinness on a rotating disk by applying a special type of temperature gradient on the disk surface. It is expected that this finding may be useful in spin coating process.

The study of Hydrodynamic Stability and Waves is concerned with the design of heat exchangers and condensers. Flow instability and formation of waves on thin film of both Newtonian and non-Newtonian fluids are of current interest. A possibility of solitons in thin film of non-Newtonian liquid flowing down an inclined plane is predicted. Deformation of free surface even in thermal convection is having considerable interest.

Turbulence problems are presumably difficult to solve due to inherent closure problems in them. Several models have been developed within the framework "Statistical Approaches to Turbulence" and applied to stratified

flows, rotating flows, flows with suspended particles, bubble plumes etc. Modelling two-phase turbulent flows is of current interest.

Research work in the area of Water Waves is deep and intensive. It involves problems on source potentials, wavemaker problems, water wave scattering and radiation problems, interface wave scattering problems, problems on wave generation due to initial disturbances, problems of incoming waves against a cliff, problems in stratified fluid. Linear theory is assumed and the emphasis is on anlytical and numerical techniques.

Interdisciplinary Research

The recent neuro-physiological experiments in the area of Brain function and congnition process challenge the century old dogma that the cerebellum participates only in motor activities. It is indicated that it participates also in cognition process. No integration theory exists so far so as to explain both these activities. The concept of generalised complementarity has been introduced so as to expalin both kind of behaviors using the idea of quantum filters. The data from patients are under critical investigation to test the viability of this approach.

The study of Dynamical Systems and Chaos concerns modelling various physical problems. They are very useful in the understanding of unfolding of bifurcation mechanisms as a function of an externally controlled parameter of the physical systems in consideration. A new type of bifurcation scenario is proposed for a model of thermal convection at the onset of convection in the limit of zero Prandtl number.

The institute has a Hydraulic Flume Laboratory attached to the Physics & Applied Mathematics Unit. This laboratory was set up in 1978 with an aim to generate multifaceted data on sediment transport. This work is interdisciplinary in nature involving a fluid dynamist, a statistician and a geologist. Mathematical models have been developed to estimate the bed load, suspended load, deposited grain size distributions etc. Sediment transport, Dispersion processes. Navigation hydraulics, MHD flow and connective flow due to heat transfer are not current interest.

In the area of Multivariable system and control theory, the focus has been on developing Numerical Methods for analysis, design and development of Multivariable Control Systems. On Realisation & Identification of systems, works have been carried out. Computational methods have been developed to decouple linear multivariable systems. Numerically reliable algorithms have also been developed to compute coprime Matrix Fraction Description (MFD) of rational transfer matrix of system. Presently, works in the area of Robust Control, Numerical Methods, Adaptive Control are being done.

In the area Bio Fluid Dynamics, the problem of blood flows through artary and cardiovasculer system, two layer model and hematocrit dependence are of current interest. Effect of temperature dependent viscosity is also under investigation.

Biological Sciences Division

The Biological Sciences Division is engaged in studying the varied biological processes covering plant and animal Kingdoms, including humans. It comprises the following units : Agricultural Science Unit, Anthropology and Human Genetics Unit, Biochemistry Unit, Biometry Unit, Chemistry Unit, Embryology Unit and Plant Chemistry Unit. Faculty members of all units participated in teaching various courses of the Institute and of other organizations. They were also actively engaged in guiding research of Ph. D. students. Research activities carried out in these units in the form of various projects are described below.

Agricultural Science Unit

Research Activities / Projects Undertaken

Crop-Soil Weather Relationship

Aim of these studies is to establish suitatable cropping systems through proper utilization of rain water and select potential and improved varieties producing stable yield under varied rainfall situation. Currently,

collection and analysis of weather data of Giridih farm where besides rainfall, other parameters affecting productivity are also being studied. Farm based trials with emphasis on rice based systems were carried out this year with above objective.

During this year, attempts were made to correlate long-term rainfall data with the performance of rice varieties during last 10 years in our farm on different land situations.

Technology Performance Studies

This work has been continuing for some time. The objective is to select sustainable ecologically suited technologies in an attempt to develop packages of farm practices related to crop/varieties on different land situations. Suitable cultivators of rice, maize, pigeonpea groundnut etc. for rainfed farming through productivity criteria based on yield and stability were identified. A few eco-friendly and economically viable low input technologies have been suggested.

Subsistent Farming Studies of Bihar Plateau Region

This work was initiated to locate the status of resource utilization, constraints for technological adoption, and to identify and examine the indigenous knowledge systems of the villages while practicing subsistence farming. A survey work was conducted at the Usri watershed of Giridih area to probe agro-ecological constraints. These include micro-level rainfall pattern as affected by environmental changes, soil resource status, technology adoption by farmers etc. In order to gain intimate knowledge of technology adoption, a complete household survey of three villages was done in the watershed area with varying socio-economic systems, productivity, ecology and technology adoption rate. The resource data have been analysed through GIS tools.

Horse gram : Biodiversity of local germplasms, their evaluation and agrotechniques standardisation

Among the pulses, horse gram is important for Bihar plateau region, since it is tolerant to drought and popularly grown in dry and upland areas. About 30 per cent of total agriculture in India is not having any irrigation facilities. Horse gram is presumed to be originated in India, hence genetic variability of this crop is expected to be maximum. Its cost of cultivation is not much and it can be used as green manure and cattle feed apart from its use for human consumption. In this situation it is necessary to improve its cultivation and productivity. We shall work to up-grade the genetic potentiality of this crop and standardize the agro-techniques.

Seed materials are collected from different horse gram growing places of Chotonagpur area of Bihar and 15 germplasms from NBPGR, Akola Centre.

Work on Palmae

The project deals with the study of various aspects of the family Palmae (Arecaceae) such as, developmental morphology, anatomy, phyllotaxy, ontogeny of endosperm in fruits, palynology, ontogeny of endosperm in fruits, palynology, ecology and conservation. Interesting findings were obtained from these studies. The work on two phases had been completed earlier. The phase III work deals with ecological anatomy of palms from different habitats, ontogeny of trichomes of leaves, and conservation of some endangered species.

Introduction of oil palm and high yielding coconut cultivars in the sundarbans area of West Bengal

The project was initiated in collaboration with the Department of Agriculture, Government of West Bengal in 1986 with the objectives : (i) to find out the possibility of introduction of oil palm and (ii) to select the most high yielding coconut palms among the well known high yielding cultivars, suitable in the Sundarbans. About 95 per cent of oil palms and 40 per cent of coconut palms started flowering.

Eco-floristic and anatomical investigations on mangroves of Sundarbans

In a continuing project on the mangroves of Sundarbans, studies were conducted with respect to their floristic survey, morphology of seeds and seedlings, anatomy of leaf, stem and root, palynology, ecology, and chemical characterization in view of their salinity stress, and medicinal properties. In the past year, interesting

results on anatomical aspects had been obtained. The work in the year 1998-99 centered on root anatomy, chemical estimation of prolines and medical properties of leaves of different mangroves.

Biodiversity of Sundarbans mangroves and identification of eco-conditions for rehabilitation of some endangered species

In this SURDAC funded project, an attempt was first made to determine the optimum size and shape of the quadrats for maximizing information on the abundance of species in the study area. Empirically it was found that both for species abundance and biomass, estimates from larger quadrats were less variable as compared to the smaller ones, there were many cases where quadrats of intermediate sizes performed better than the largest size. Further study in this line is in progress.

Anthropology and Human Genetics Unit

Apart from carrying out research work in different areas of Biological Anthropology and Human Genetics, faculty members of the AHGU regularly participated in teaching in various courses offered by the Institute and Calcutta University. Some of the faculty members are also engaged in Supervision of Ph.D. theses.

Research Activities / Projects Undertaken

Health Status and Labour Productivity

A project was undertaken under the title of Health status and labour productivity in order to find out casual relationship between health and nutritional status of a labourer with his/her work output. The study has been designed to identify the intervention points also of productivity of a labourer. Agricultural labourers were chosen for the present study and all the data have been collected. Complete analysis have not yet been done. Preliminary analysis show that the threshold age for peak physical activity is 30-34 years in case of males and 25-29 years in case of females.

Effects of Microenvironmental Factors on Health in Rural Populations

In the past year, demographic data collected from Munda (tribal) and Poundra (Hindu) living in the similar habitat, and more or less same working pattern, were analysed in order to compare the infant mortality rates among these groups. The study in the year 1998-99 focussed on the effect of working patterns of the mothers of these infants. It was found that while the previously observed differences among the groups prevailed even in the presence of the new information. Further, the infants with working mothers were found to have higher mortality rate than those with non-working mothers.

Women's Studies : Health and Well Being

The ongoing phase of the project aimed to evaluate health status of women over their entire life span -- on the perspectives of joining out-of-home employment in the city of Calcutta.

The group studied included women at their prime working age and at their age of retirement and beyond.

From the results obtained so far, and from the various other studies, it can be generalized that women, who lived mostly in dual earner households, seldom reports feelings of high stress though they still have to take on responsibilities for household management and child rearing. It can be presumed that with respect to the relationship with the family, the couples probably try to maintain an accommodating relationship between themselves, which helps them to take on collaborative attitudes in the family, which in turn might help mitigate the stress, if any. In general, the retired individuals, irrespective of gender, were shown to have more psychological disturbances. The non-retired group, often reported to have more spouse support compared to the retired one.

Determinants of Health Among the Hindus and Muslims Living at Different Cultural Settings

Health seeking behaviour is one of the main components of health culture of a community. Health culture is one of the major components of the total way of life of human beings.

Each community has its own cultural identity. With the development of various health institutions bring about changes in health culture of a community. Access to health services and health care delivery system determine the cultural responses of the community.

A same community is sometimes found at different culture-i complex (from remote rural village to the Industrial and further to stressful city). Thus there is a change in health culture at different social millieu.

With the above end in view, the Hindus and the Muslims living side by side in adjacent but different clusters were selected from (1) a rural village in WB, (2) one Industrial town in WB and (3) an urban (stressful) slum in Calcutta city. It is also planned to collect data on the Buddhist Tibetan refugees living in Ganjam district, Orissa.

Modernization and Health in the Sikkim Himalaya

The project is aimed at examining the relationship between modernity of lifestyles and health characteristics among the Bhutias, a tribal population of Sikkim

So far, socioeconomic information and qualitative information on food habits, health care practices have been collected from about 85 rural Bhutia households inhabiting 5 villages in South Sikkim.

Genetic Diversity of Indian Populations

Based on data gathered from relevant publications, this project focusses on carrying out statistical analyses for obtaining profile of genetic diversity and affinities among Indian ethnic groups on an all-India scale. Compilation of data, estimation of gene frequencies and genetic diversities have been completed. Most populations are found to harbour a great deal of diversity. Further analysis on determination of genetic affinities are in progress.

Genetics of Complex Traits

In the area of human genetics, research on the following themes are being pursued : (a) genomic diversity in ethnic populations of India, with a view to udnerstanding evolutionary histories of populations, tracing trails of prehistoric migrations and the genetic structures of populations, (b) identifying genetic and environmental factors underlying complex human disorders, (c) developing statistical methods for understanding and mapping the genetic architectures of complex traits. Some statistical models useful for the study of multilocus dichotomous traits have been proposed and applied to family data on vitiligo. Statistical procedures for the mapping of quantitative traits are currently being developed.

Chaging patterns of Resource Use and its Biosocial Implications : An Ecological Study Among the Gangtes of Manipur

(a) A project on Genetic microdifferentiation among the Golla subcastes was carried out, using hyper variable DNA markers, and these were compared with the trends based on the traditional quantitative variables among the same. This study has been first of its type in examining the process of differentiation at the lowest level of human population hierarchy, using the DNA markers. This study helps in examining the usefulness of STR markers in such studies and their relative superiority to the tradiional quantitative variables. This work was carried out in collaboration with the universities of Kansas and Cincinnati, USA, as a Visiting Fulbright Scholar

(b) During the year two ongoing collaborative project on the (i) Biological affinities between the migrant and parental populations of fishermen on the East Coast of India, and (2) Quantitative Dermatoglyphics and Population Structure in the North West India have been finalised. As part of these projects examined the patterns of gene flow into migrants and among the North Western populations, using R-matrix analysis.

Genetics of Dermal Ridges

The objectives of this project are to study (i) Population variation in respect of dermatoglyphics and dermatoglyphic asymmetry, (ii) Association between palmar and plantar dermatoglyphics, (iii) Inheritance of dermatoglyphics (iv) Inheritance of dermatoglyphic asymmetry, (v) The asymmetry of some bilateral anthropometric traits along with some other measurements, their inheritance and association with dermatoglyphic character. Data of 500 families from 5 different endogamous populations are being used for this project.

Human Growth

Analysis of data on the assessment of nutritional status of the adolescents following the WHO (1995) criteria has been done. Primary arrangements for a repeatative growth survey has been completed.

Epidemiological investigations on genetics and environmental factors related to diabetes

The study of epidemiology and some clinic- genetical aspects of diabetes mellitus, aims to specify the needs, monitor long term complications and select the proper management for those suffering from this grievous disease.

Genetic survey of some endogamous groups of Northern India

Genetic survey has been conducted in three different geographical regions of Uttar Pradesh : (1) Garhwal region (near Mandakini Valley), (2) Lucknow and (3) Varanasi. About 1600 blood samples were collected from five caste group, one tribal group and one other religious group. Biochemical polymorphism and DNA polymorphism have been screened in the laboratory, several phenotypic variant in biochemical markers have been found, such AK1 ADA, 6PGD, G-6PD, PGM1 and MDH.

Gene Environment Interaction

Studies on susceptibility genes, which make an individual susceptible to different diseases e.g. oral cancer, antituberculosis drug induced hepatotaxicity, are being persued. It has been observed glutalohicase-s-transferase M1 'null' mutation increase the risk of an individual to tobacco induced oral cancer and antituberculosis drug induced hepatotoxicity.

Biochemistry Unit

Research Activities / Projects Undertaken

Human Uterine Cervix Cancer Database : Molecular Epidemiology (partly under SURDAC funding)

The major cancer burden of the female population of India is uterine cervix cancer. By the time most cases are reported, the stages are advanced and fatal. It has been projected that the number of annual incidence of 0.09 million in 1986 will be increased to 0.14 million by the turn of the century. Prevention and control of many of these premature death is, therefore, worthy of serious consideration, especially, in the context of women health in India.

Cancer of cervix starts with a pre-invasive curable stage, cervix dysplasia, which is considered as a pre-cancerous lesion. There is a large body of evidence, which indicates that effective cervical cytology screening (Pap test) program could result in reduction of mortality from cervix cancer. Moreover, it becomes necessary to have an insightful grip on various relations and dynamics present among the key factors [such as Pap and Human Papilloma Virus (HPV) infection indication, age at registration (Age), age at the consummation of marriage (ACM) and Parity (P)] of the process

The process of cancer building is quite complex and non-linear in nature. A 'forward search' approach to model building was adapted in this context. First, Pap screening data collected from Calcutta Medical College Hospital (CMCH) on women were studied in order to understand the nature of relationship between Pap indicator and various demographic and socio-economic factors. A simple model search using multiple correlation identified

the major factors as Age, ACM and P for prediction of Dysplasia status. Further analysis revealed some possible dependence between Pap status indicator and P. The Pap indicator, however, was obtained through cytological tests, and showed strong possibility of being subjected to measurement error. This led to the second component of investigation, where a regression analysis based on calibreated posterior (RACP) technique was developed for scaling ordinal measurements using proportional odds model. This is applicable whenever experiments are replicated on the same subject.

The next phase encompassed a retrospective study on cervix cancer patients. Information on the presence of HPV (16/18) has been collected along with other cyto-and histopathological information. The viral load and types HPV 16/18 in this neoplasia in 66 cervical biopsy specimens was investigated in order to study whether any association existed between the two. By analysing the data using 2x2 contingency tables, it has been found that HPV positive tumors are prevalent (77 per cent) with higher numbers of HPV 16 (73 per cent) followed by HPV 18 (20 per cent). The data further revealed that HPV infection had a strong association with Clinical staging and histopathologic grading, but none with Age, Age at the consummation of marriage or Parity.

In the final phase, data were collected through in-depth field visits on a number of women. For each subject, a pap smear, a smear for Gram-test (mainly for diplococci infection) and a cervical lavage for HPV-assay were taken. A check-list with several demographic variables, such as Age, ACM, P; life style-variables like dietary and other habits, marital/extra-marital history; biological, such as, menstrual, obstetrical, contraception history, past medical history, if any. Added to these are, clinical, cytological, any STD-problem and HPV-indicators with follow up visits. A total of 360 subjects have so far been enrolled with 45 follow up (at least one) visit.

Folic Acid in Cervical Preneoplastic and Neoplastic Diseases

The study remained focused on women with cervical dysplasia/cancers to investigate several aspects of the role of folic acid in neoplasia. A major question is whether folic acid play any role in programmed cell death [PCD] (through apoptosis) during the process of normal maturation and differentiation of cervical epithelium versus in the abnormal cell proliferation.

In the past years, apoptosis in cells from cervical scrapes of women who are risk for the development of cervix dysplasia/cancer were studied along with controls.

Development of in vitro Model for Carcinogenesis/Tumorigenesis

There has been a need for a model system for the study of carcinogenesis/tumorigenesis. A human peripheral blood lymphocyte culture system was established to explore the possibility of using it for developing markers (through apoptotic mechanism) for tumorigenesis. The study began with lymphocytes from normal individuals (with wild type p^{53} gene that is known to promote apoptosis). Such cells were found to be resistant to the induction of apoptosis by H_2O_2 with a marked improvement of proliferative capacity. When a pre-treatment with a small non-toxic concentration of H_2O_2 exposures. Further studies are on to elucidate the underlying mechanism of such resistance which could be important with respect to various pathological conditions, especially cancer.

Molecular Mechanism(s) of Defence Against Oxidative Stress : Cellular, Biochemical and Genetic Aproach

Resistance to oxidative stress is often associated with cellular transformation. The objective is to identify some of the molecular mechanisms of resistance to oxidative stress with emphasis on apoptotic cell death, in a cell strain M5 derived from V79 cells. The M5 strain was found to be resistant to cell killing by gamma rays and H_2O_2, compared to the parental V79 cells. The M5 cells were also found to have, 3-fold higher GSH (a molecule that buffers oxidative free radicals) level and an inhibition of induction of apoptotic cells death by H_2O_2 compared to the V79 cells. To find out if enhanced GSH levels in these cells were responsible for the altered apoptotic pattern the GSH pool of these cells was depleted by treatment with a drug, BSO, prior to induction of apoptosis by H_2O_2. No enhancement was observed. This indicated that increased GSH level was not responsible for the resistance to apoptosis in M5 cells and probably implicated the existence of other factors. In case of parental V79 cells, such depletion of GSH enhanced the apoptotic response in these cells to H_2O_2. Since the parental V79 cells were established to be homozygous (-/-) p^{53} mutants, this would be true for the M5 cells as well. Therefore, while

presence of normal p^{53} is essential for the induction of apoptosis, in these cells the process is mediated by a p^{53} independent pathway. However, another gene product which is known to inhibit apoptosis, is BCL-2, which is also established as an antioxidant. Thus, ruling out the involvement of GSH, BCL-2 expression might be one of the other factors involved in the inhibition of apoptosis in the M5 cells, compared to the V79 cells.

Biometry Unit

Research Activities / Projects Undertaken

Fishery Science

Conventional statistical methodologies pertaining to the analysis of longitudinal growth data of Indian major carps are being applied to the live data generated in the Laboratory. Autoregressive and finite difference methods applied parallely indicate the "problem area" of growth where negative velocity and acceleration of growth was observed. Well-formulated nutrients supported by linear programming method are being applied to remove the "degrowth" stage of the species. Rao's polynomial growth curve model is currently applied to predict the growth of the species by cross validation. Directional data are being generated by installing the hoopnets in a 'rose diagram" design in the pond. Results so far obtained indicate the predominance of "between direction" variation over "within direction" variation of the dissolved oxygen content of pond water which contributes largely to the growth of the species.

Malutrition related Rickets in childhood Diabetes

The research tried to find out how and why rickets develop in patients suffering from malnutrition and undernutrition. The focus was on some errors in dietary intake of the experimental subjects, since they are linked to all types of diabetes specially type II or NIDDM. Investigations were carried out to (a) make a dietary survey to find out the prevalence of these dietary errors in different communities, (b) to detect dyslipidaemia, atherosclerotic disease of type II diabetes among those survived and (c) to correlate dietary errors with atherosclerotic disease, dislipidemia and type II diabetes.

From the experimental findings some interesting results were found which are different from those of other workers of the World. A particular HLA-class II antigenic association in our patients has been observed. These steered to extend these findings to other types of diabetes such as IDDM and NIDDM.

Development of hypoglycemic drug from Gymnema Sylvestre leaves

In order to study the effect of Gymnema leaves on blood glucose level, after determining the LD_{50} and working dose of the leaf extract, its role on blood glucose level of (a) Normal (b) glucose fed hyperglycemic (c) adrenaline-induced hyperglycemic and (d) streptozotocin induced diabetic rats was studied. Further studies are going on to observe some other parameters for its blood glucose lowering action.

Besides this, studies of the effect of Isoleukin-8 (IL-8) on some infectious diseases, specially diabetes and cancer are being carried out in collaboration with the Immunology Department of Indian Institute of Chemical Biology, Jadavpur.

Chemistry Unit

Research Activities / Projects Undertaken

Distribution of Heavy metals and related micronutrient elements in soils of West Bengal.

The project deals with heavy metals in presence of various soil components. Natural levels of fertility are seldome adequate to sustain a resonable long term degree of agricultural productivity. Deficiencies can occur in soils either because they contain extremely low concentration of trace elements or because the elements are present

in unavailable forms. It is therefore essential to be aware of soil nutrients reserves the likely crop requirement and ways counteracting a shortfall between the two.

Adsorption of Heavy metals on soils.

In the interaction between the solid phase of the soil and solution, physico-chemical or exchange and adsorption is as important as chemical and molecular ones. It is particularly manifest when cations Cu, Zn, Co, etc are adsorbed by the solid phase.

Embryology Unit

Research Activities / Projects Undertaken

Biomathematics of morphogenesis and carcinogenesis

In a continuing study, mathematical and stochastic models of pattern formation and morphogenesis during early embryonic development has been further investigated. Application of advanced mathematical tools of nonlinear analysis, bifurcation analysis, global stability, control theories, probalities theories etc. have been used to study the complex biological systems. The periodicity of the observed pattern after inclusion of negative cross diffusion has been confirmed through Hopf-bifurcation analysis in a nonlinear reaction diffusion model of cellular differentiation and growth during embryogenesis. Investigations on the mechanism of carcinogenesis through Turing structure and contact cell inhibition of mitosis have been considered. Another nonlinear reaction diffusion model of cellular differentiation and consequent pattern generation during embryogenesis has been proposed and analysed. Hopf-bifurcation analysis has confirmed that the inclusion of a negative cross diffusion can maintain a wave like solution and give rise to a dissipative structure.

Intercrop interaction - a mathematical study of Agricultural Ecology

Allelopathic interaction through root exudates (RE) of different varieties of rice and wheat as well as between different varieties of crops has been further investigated. The work on allelopathic effects on weed crop interaction, and Tamarindus plants have been pursued. Inhibitory and stimulatory substances in pulpsi of different fruits have been further investigated and ecological aspects of delayed germination have been studied. Possibility of the use of this inhibitory and stimulatory properties of fruit pulps in agriculture have also been considered. For example, some fruit pulps, having inhibitory substances, may be used for weed control and those having stimulatory substances may be used as biofertilisers. The composition and properties of allelopathic agents of RE have been analysed with the help of GLC, UV spectrometric, and MS analysis. Development of mathematical models on these aspects are in progress.

Mathematical Epidemiology

Mathematical and stochastic models of Japanese Encephalitis (JE), measles and other vector-borne diseases have been proposed and explorative analysis have been made with special emphasis on seasonal fluctuations and spatial spread. Two situations for the spread of JE, namely, a two populations model consisting of pig and mosquito and another two populations model consisting of pig and human being have been considered.

JE is not considered essentially to be a disease of human being in the sense that the cycle of JE can not be maintained without amplifying vertebrate animals and man is the dead end of infection. Pigs are probably the most important amplifying animals in India, Japan , Thailand, Malayasia, Bangladesh and some other countries and the human epidemic of JE receives a direct influence of the pig epizootic. For these reasons a mathematical model with continuous variables, consisting of two populations of which one is reservoir (pig) and the other is vector (mosquito), has been considered. It has been observed that the inensity of infection in the pig population increases with the number of mosquito bites per pig upto a certain threshold value. This result is consistent with the natural phenomena. Detailed analysis of the model to explore the global properties is in progress.

Diffusional effects on two or more interacting species in community ecology

A three species eco-epidemiological system namely, sound prey (susceptible), infected prey (infective) and predator has been considered. The case when the predator mainly eats the infected prey has been considered. The persistence and extinction conditions of the populations have been derived. The conditions for which the system enters into a Hopf-type bifurcation have also been derived. Moreover, It has been observed that the bifurcating branches are supercritical in some region of parametric space in a special case when the predator response function is of Holling type II.

A study of a two dimensional system that arises in Plankton Allelopathy involving discrete time delays and environmental fluctuations has been investigated. The environmental parameters are assumed to be perturbed by white noise characterized by a Gaussian distribution with mean zero and flat spectral density. The dynamic behaviour of the stochastic system is studied and the fluctuations in population are measured both analytically and numerically by computer simulation.

Plant Chemistry Unit

Research Activities / Projects Undertaken

Screening of Local vegetation

A field trip to the Agricultural Experimental Station, Giridih was undertaken to study the multiple uses of the various tree species growing in the lateratic tract of Bihar plateau. Soil samples were also collected from different locations and parameters like pH, moisture, temperature, total nitrogen, organic carbon, available phosphorus and available potassium have been analyzed. The total nitrogen content of surface soil (0-15 cm) ranged from 0.5 to 1.23g/kg and that of subsurface (30 cm more) varied from 0.40 - 0.58 g/kg. The total nitrogen content in the soil profiles under forest cover decreased systematically with increased depth. Microbial counts of soil samples showed that sufficient number of bacteria, fungi and actinomycetes exist in all the sub-zones namely, Tarr land, mixed forest, sisoo and subabool forest ranges.

Microbiology & Technology

Fibrous by-product left during leaf protein extraction from two woody perennials were analyzed for their chemical composition. Recorded chemical components of *Cassia siamea (CS) and Anthocephalus kadamba (AK)* are as follows - CS ash 5.7 per cent, crude fat 11.3 per cent, lignin 36.93 per cent, holocellulose 44 per cent, α -cellulose 19.41 per cent, pectin 12.07 per cent. Particle boards using the by-product have been prepared with 15 synthetic resins such as urea formaldehyde resin and phenol formaldehyde resin.

Nutritional and biochemical studies

A study was conducted on the utilization of pressed fibre residue left after extraction of leaf protein from *Dalbergia sisoo, Cassia bicapsularis, Cassia siamea and Limnophila heterophylla.* Although the nutritive value of pressed fibre residues were almost comparable to that of the original plants, but to improve the feeding value some chemicals like urea & NaOH, were added. It was found that with the addition of urea the protein content of the pressed fibre residues improved significantly. Chemical analysis showed that the ash content of the pressed fibre residue treated with NaOH is slightly higher than that of the untreated one.

Aquatic weeds and water relationship

Monthly anlaysis of water quality parameters like pH, temperature, conductivity, total dissolved solids, free CO_2 and dissolved oxygen are being done on a local pond to assess changes in its water quality. Sampling conducted from February 1998 to November 1998 showed pH values ranging from 7.7 to 8.3, temperature ranging from 23° to 32° C, free CO_2 values ranging from 3.73 to 27.98 mg/L, conductivity ranging from 113 to 138 Ms/m and dissolved oxygen values ranging from 0 to 7 mg/L. Water weed samples when present, were also harvested and the plant samples analyzed for dry matter, crude protein, and ash contents.

Yield performance

Sugarbeet varietal trial was undertaken on four varieties namely, Rospoly, Solid, Virtus & Mezzanopoly to study their yield performance in comparison to Ramnaskaya 06. Root yield, shoot yield, dry matter, protein nitrogen extractability and leaf protein yield and sugar yield of the varieties are being studied at every 20 days interval starting from 80 days after sowing. Ethanol production from the root of different varieties will also be studied.

Enzymes from soil microbes

Among the seven strains of Bacillus (Bacillus licheniformis PC1, B. Licheniformis PC 2, B. Coagulans, B. Polymyxa, B. Subtilis, B. Cereus, B. Magaterium from different rice fields under alluvial soil tract, Bacillus licheniformis PC 1 was found to be a good producer of extracellular alkaline protease. The production of alkaline protease was high in glucose - yeast extract - asparagine medium (12unit/ml) and starch soymeal medium (16 unit/ml). The enzyme yield increased rapidly after 18 h of incubation and reached a peak at 50 h. Protease production was best at pH 7.5-8, the optimum temperature for enzyme activity was 60° C.

Social Sciences Division

The Social Sciences Division includes the following units : Economic Research Unit, Economic Analysis Unit, Linguistic Research Unit, Planning Unit, Population Studies Unit, Psychology Research Unit and Sociological Research Unit. Economic Analysis Unit is located at Bangalore, Planning Unit is located at Delhi, while the remaining five units are located at Calcutta. Faculty members of this Division participate in teaching and training activities at various levels, including Ph. D. supervision. The research work done in these units during the year under review is described below.

Economic Research Unit

The faculty of Economic Research Unit was actively involved in research, training, project work and supervision of Ph.D. students. One student has been awarded the Ph.D. degree in the last convocation.

The faculty members and scientific workers of the Unit undertook research in a wide range of topics in Economic Theory, Quantitative Economics and Econometrics. Areas of research included Industrial Economics, problems of Small Scale Industries, Agricultural price formation, Welfare economics, International Trade, Issues in Economic Development and Macroeconomic Policy in India, Analysis of Consumer Behaviour, Level of Living and Gender Bias. Studies on quality of Life, Environmental Economics, Economics of Tourism, Econometric Theory and Applications and Sampling Techniques. These researches have been published/accepted for publication in internationaly reputed journals like Journal of Economic Theory, Theory and Decision, Economics Letters, Keio Economic Studies and Manchester School.

The teaching and the training activities included both Ph.D. research supervision and teaching in various academic programmes of the Institute, such as the B.Stat. (Hons.), M. Stat., M. Tech. (QROR), MS(QE) and ISEC (Regular and Special Courses).

Projects Undertaken

A. Externally Funded Projects

Environmental Management Capacity Building Technical Assistance Projet - Environmental Economics Component

This is a World Bank aided project assited by IDA and funded by the World Bank which is being implemented through the Ministry of Environment and Forests, Govt. of India. The duration of the project is five

years beginning 1997-98. The Economic Research Unit got involved in the project in 1998. The broad objective of the project is to strengthen the environmental management capability of the country. The environmental economics component mainly aims at enhancing the capability for the application of economic principles and tools to environmental management problems across the full range of issues such as cost benefit analysis of alternative policies for pollution control, resource management and biodiversity conservation. A number of the project proposals have been prepared during 1998-99.

Training Programme in Environmental Economics for Government Officials (18-23 January, 1999)

The programme, which was funded by the World Bank, was attended by twenty participants from all over India. The participants were officials from various government departments dealing with environmental problems. Quite expectedly a large number of participants came from pollution control boards of West Bengal and neighbouring states e.g., Manipur, Tripura, Meghalaya, Assam, Andhra Pradesh. Persons from Central Pollution Control Board, New Delhi and Planning Commission, Govt. of India also participated.

The primary objective of the Programme was to introduce to noneconomist participants facets of interrelationship between economy and environment, the ways through which human activities give rise to environmental pollution requiring suitable policies to control/abate such pollution. Participants were taught how to make economic valuation of environmental and natural resources and made aware of the comparative advantages and disadvantages of various pollution control techniques, like taxation, subsidies, sale of tradable pollution permits etc. The resource persons were eminent teachers of the well-known Institution/Universities in India engaged in research in environmental economics. This is the first time that a training programme like this was organised for government officials in the eastern region of India.

B. Plan Projects

Identification of Causes of Sickness of Small Scale Industrial Units

The main purpose of this project is to identify the causes of sickness to empirically verify the viability of small scale industrial units in the wake of recent liberalization in India. The underlying work involves assessing the incidence of sickness in the small scale sector and studying (i) the factors responsible for such sickness, (ii) technical efficiency, (iii) wage productivity linkages and employment potential of small scale units and (iv) mode of production and marketing channels.

The duration of the project is two years. A survey on the small scale industries located in the regions Calcutta, 24 Parganas, Hooghly and Burdwan has been conducted during the period April 1998-March 1999. The data are being entered into the computer for analysis.

Level of Living and Employment : Study of Patterns and Interrelationships Based on Household Level NSS Data (SURDAC funded)

A part of the project has been completed. The effects of household demographics on consumption pattern, measurement of cost of child and consumer equivalence scales have been examined using NSS household level consumption and employment data for the 43rd and 50th rounds.

Economic Analysis Unit

Apart from research and projects, the members of the faculty participated in the teaching of various courses offered by ISI and the Indian Institute of Management, Bangalore.

Research Acitivities / Projects Undertaken

The broad areas of research include theoretical and applied economics and econometrics. Active research work was carried out in frontiers of econometrics and in several areas of applied macroeconomics, game theory, agricultural economics, econometric modelling and Bayesian Econometrics.

Recent Developments in Applied Computable General Equilibrium Models

One of the important aspects in this area is modelling the role of government sector. A major difficulty in the modelling is the corruption in public offices. If economic decisions by the goverment were a consequence of corrupt deals of a few individuals rather than due to economic rationality, most of the available economic data base becomes inadequate. Not only economic but also political variables become essential for such modelling. Data on political variables and/or corrupt deals usually do not exist. Besides, even economic variables have to be (dis)aggregated, or classified differently. It is no longer adequate to classify people into mere (low, average and high) expenditure/income groups. They need to be classified into power groups, pressure groups, lobbyists, the bureaucracy, powerless workers and so on. Income generation and consumer expenditures have to be modelled accordingly. Justification of the government interventions, rationality of the government behaviour, theoretical and data inadequacies to model the government operations, political pressures behind the government expenditures, etc. are some of the issues that have been studied.

Application of Bayesian Econometric Methods for Solving some Long-Standing Problems in Economics of Inventory Investment Analysis

Inventory investment has long been identified as the major component of the changes in the Gross Domestic Product. The two most widely used models for determinants of inventory behaviour were the Flexible Accelerator and the Buffer-stock/ Production Smoothing models. However, empirical findings contradict one another on the question whether firms attempt to smooth production. On the other hand, in the case of the Flexible Accelerator model, the unreasonably low speed of adjustment of inventory stocks to the desired levels. It was suggested that the low speed of adjustment may be in part due to biased estimation procedures. Specifically, the problem can be attributed to the use of seasonally adjusted data, artifacts of aggregation bias, over both firms and industries, as well as temporal aggregation. A further complication is caused by the use of lagged stock of inventories which lead to serial correlation in the residuals. The joint research with Western Washington University, USA has resulted in developing a Bayesian estimator applicable to models which include both lagged dependent variables and auto-correlated disturbances. The empirical evidence by applying this new estimation method to monthly industry data which have not been seasonally adjusted showed that the low speeds of adjustment reported in the literature, as well as the low degree of production smoothing may indeed be artifacts of the estimation procedures used. The methodology developed can be used in several econometric models where the relationship between reduced form parameters and structural form parameters are non-linear.

External Assistance and its Impact on Long Term Growth and Development

This has been a long debated issue among economists. The unit in collaboration with Bangalore University, undertook the research to see if the existing studies were carried out using correct statistical procedures. It was found that most of the earlier empirical studies relating to India ignored the problems arising from time series data and never tested for unit roots and non-stationarity. As a result the conclusions and the policy implications have been faulty. This research is continuing.

VAR Model for the Financial Sector of India

This is a collaborative work which also involves the Reserve Bank of India. The model is expected to serve as an important policy making tool for the highest Bank in the country. Dynamic optimization problem has also been worked on to look at the North South trade regime.

Other research activities carried out by the unit included study of merits and demerits of the Participatory Project Appraisal methods for rural development, access to irrigation water for poor farmers, advances in estimating frontier production functions.

Linguistic Research Unit

During the period April 1998 to March 1999, the Linguistic Research Unit continued its programme of research in the areas of Quantitative Linguistics and Computational Linguistics with special emphasis on speech pathology, psycholinguisitics, sociolinguistics, syntax and text analysis.

Research Activities

Computational Linguistics

The work in this area focussed on valency-based natural language processing, fuzzy logical expressions in Bangla, the problem of conceptual tense and aspect vis-a-vis grammatical tense in Bangla discourse.

Methods in Quantitative Linguistics

Several methods in this area were studied.

Studies on the Phonetic and Phonological Structures of Major Indian Languages and Applications

Applications of the study of phonetic/phonological structures in the areas of speech pathology, second language acquisition, cultivation of mother-tongue, language standardization and comparative suprasegmental studies on Indo Aryan, Dravidian and Slavic languages, were considered.

Sociolinguistics

The major areas of work were study of language attitudes, language maintenance and shift, measurement of bilingualism, linguistic sub-alternity and decentralized language planning in a plural society and analysis of folklore and folklanguage.

Clinical Linguistics

Aetological and diagnostic approaches were considered.

Psycholinguistics

The relationship between "empty linguistic organism" and "social malleability" were studied with soecial reference to the psi-properties.

Post-Structuralism

The post-formal approach to linguistics and the archeology of Bangla grammer were studied.

Projects Undertaken

Quantitative Linguistics

The major objective is to develop indigenous methodology for the quantification of micro and macro linguistic corpus and to develop software packages to analyse existing corpus. The areas which are to be covered are lexicology, semantax, sociolinguistics and text analysis.

Comparative Suprasegmentals of the Austric, Indo-Aryan and Dravidian Languages

The major objective is to conduct a comparative study of the suprasegmentals of language belonging to the language families in question. The results are expected to be useful in the diagnostics and treatment of children with language disorders.

Language Processing and Planning

The project has two focal areas: (i) to analyze Bangla sentence structure in computers by deploying valency-based surface syntactic analytical method, and (ii) to study the problems of computational linguistics related to natural science and social science problems as well as problems related to philosophy of sciences. The

analysis of Bangla sentence structure in the first phase has been completed. It has been possible to expose the limitations of computational linguistics with relation to the areas under review.

Bangla-English Interference : An Item Response Theoretic Approach

This project tries to gauge the impact of Bangla (L1) on English (L2) on the middle and secondary level of education in West Bengal. In the initial phase 800 respondents from middle secondary level in West Bengal were administered a test using the IRT approach.

Glottopolitics of Linguistic Subalternity in Multilingual India

The project solely devotes to analyze the linguistic demands of different Indian Communities in highly movement-prone zones. So far, the project has covered Santali, Rajbansi, Gorkhali and Pahari languages in this regard.

Planning Unit

The Unit's research activities spanned a wide range of areas covering abstract economic theory to applied economics. In particular, the creation of the Planning and Policy Research Unit (PPRU), which is a permanent research centre within this unit, has proved to be immensely useful in facilitating policy-oriented research in the unit. The PPRU is financed by an endowment provided by the Planning Commission. A brief account of the various projects financed by the PPRU is given at the end of this section. Several members of the Planning Unit have continued to work on issues relating to poverty and income inequality during the year. Major areas of research are described below.

Reserach Activities / Projects Undertaken

A. Externally Funded Projects

Dynamics of Poverty in Rural China

This project was funded by the World Bank. The study was made on the basis of a six year Panel Data Set from four Provinces in South-West Rural China. Several methodological advances have been made. These have been reported, along with the empirical findings, in several publications listed elsewhere.

Assessment of the Economic Impact of Public Works Programs on the Poor

This project was also funded by the World Bank. This research made some methodological and empirical contributions. The empirical study was based on a government sponsored public works program in Argentina. Another outcome of this reserach has been a proposal to look at similar impacts of the public works and the IRDP programs in India and relate it to the decentralized implementation of such schemes.

B. Plan Projects and Other Research Activities

Environmental Degradation (Proxied by Carbon Emissions) and Economic Inequality

Research has been carried out by using cross country panel data. A paper on this work has been listed elsewhere.

Role of Infrastructure in Growth and Development

The essential idea is that infrastructure is often a public good. Hence, its provision through markets raises complicated pricing problems. A paradox arising out of inefficient pricing in pseudo-market economics was exposed. The market driven economy, which is unable to internalize, grows faster than a planned economy which internalizes all externalities. Fast growth, therefore, is not necessarily a sign of efficiency. In a related work, a Lindahi pricing scheme was derived to show that the planned economy's growth path is sustainable in economics

driven by private profit motives, provided a dual pricing scheme is implementable. The possibility of free infrastructure provision was also considered to avoid the pricing problem. In this set up, it is found that while a growth maximising path exists in the class of steady states for pseudo-market economies, there is no welfare maximizing solution. Paradoxically, the planned economy yields a welfare maximizing unique path. So far, the paradox remains unresolved and current efforts are devoted towards solving this problem.

Mechanism Design

This research was conducted jointly with Universitat Autonoma de Barcelona to analyze the possibility of constructing strategyproof social choice correspondences. Further collaboration with university of Maastricht have been done on strategyproofness of stochastic outcome functions on so-called economic domains. Work has also been done on characterisation of preference domains over which the requirement of strategyproofness implies that the social choice function must satisfy properties such as "tops onliness", anonymity and dictatorship.

Incentive Properties of Deterministic Models

The research work studies the incentive properties of deterministic models where compensation is feasible. This has applications in the theories of auctions and queues.

Strategic Candidacy in Elections and Committee Decision Procedures

The object of this study was the widely observed practice of some candidate(s) withdrawing from an electoral contest in order to secure a more favoured outcome. The principal result shows that it is impossible to construct any reasonable procedure which is immune to strategic candidacy.

Learning Dynamics

The global structure of learning dynamics in general equilibrium/ macro formulations have been studied, to get an understanding of when rational expectations are likely to emerge as the outcome of learning. Applications of these results to overlapping generations economics is being studied in colaboration with the Universite of Alicante.

Sequential Market Game

The research was conducted jointly with the University of Warwick. The study focussed on the coordination of expectations in the vicinity of a well behaved Nash equilibrium, which converges to the competitive equilibrium, as the number of agents becomes large. The purpose of the exercise is to understand when a perfect foresight competitive equilibrium can be rationalised as a stable strategic outcome of a large market game with explicit trading rules which agents take into account in their strategic behaviour.

Industrial Organisation

The work in this mainly involve predation and mergers, as well as the leasing of durable goods and market segmentation. A study was also iniciated jointly with the World bank on home ownership, community interaction and segregation.

International Trade

In recent years, many countries have witnessed substantial changes in the degree of wealth and income inequality. Free international trade is alluded to be one of the contributory factors. But there is a general lack of theoretical analysis of the ways in which trade policy may affect the personal distribution of wealth and income. One of the central conclusions reached through this study is that free international trade and the opening up of financing markets betwen developed and developing countries are likely to increase inequality in the former and decrease that in the latter. This process may lead to middle class boom in the latter.

Gender Bias in Children in Rural Maharashtra

The evaluation was done on the issue of gender bias in terms of disparities in the intra-family allocation of consumption goods. National Sample Survey 1993-94 household consumption data was used for rural Maharashtra. Some what surprisingly, the research found some evidence of a bias in favour of female children, thus negating the widespread belief about the existence of discrimination against females.

C. PPRU Projects

Gender Bias in India

The project examined the extent of gender bias in health and education in India over time, and also analysed possible explanations for the observed pattern of discrimination in infant and child mortality rates, as well as in gross school enrolment rates.

Link of Poverty with Gender of Head of Household

This was a collaborative project with North Eastern Hill University, Shillong and SERFA. Using NSS 1987-88 household consumption data, it was investigated whether households headed by females are more vulnerable to poverty than those headed by males. It was found that there is a clear gender bias in the incidence of poverty, even after controlling for differences in education levels and land holdings.

Porter Hypothesis on Environmental Regulation

This project, conducted in collaboration with Vanderbilt University, led to a simple analytical framework to support the Porter hypothesis that stricter environmental regulation will both succeed in making firms greener and also enable them to differentiate themeselves from their competitors.

Computer Industry in India

The project focused on the quality, performance and evolution of firms in the post-economic liberalization era.

A Study of the Indian Iron and Steel Industry

This was a collaborative project with JNU, New Delhi. In the analysis of relative roles of quantity of natural resources and human resources, it was found that the former appears to have a more important role in determining productivity than human capital. The skill level of human labour is more important in reducing delay and raising capacity utilisation than in increasing the productivity of equipment per unit of time.

Comparative Economic Development of Indian States Over Time

The study was conducted in collaboration with ISI, Calcutta. The principal motivation of this study was the convergence hypothesis of modern growth theory.

Economic Reforms of Agriculture

The project was carried out jointly with University of British Colombia. The main conclusion was that a certain kind of rural growth based on market opportunities, urban-rural linkages through the use of producer services and diffusion of technologies is most likely to succeed in rural India.

India and ASEAN : A Case for Closer Economic Co- Operation in Trade

A principal finding of the study was that bilateral trade ties between India and ASEAN countries cannot prosper unless the Indian export basket changes in favour of intermediate products of heavy and chemical industry.

Population Studies Unit

Reserarch Activities / Projects Undertaken

Digit Preference Error in Age Data : Implicit Model Approach

Indices have so far been constructed to measure the extent of digit preference error in age data (single year) either from census or survey. All indices possess deficiency in their constructions. As such modifications are done at different steps by different researchers and modified indices sometimes are of little value in their use because of cumbersome calculations. The present method, however, tries to highlight some theoretical conditions under which all the extraneous sources of variations are eliminated implicity in a single attempt leaving behind a true index.

Women's Education and Employment in India, 1951-1991

The study is undertaken to find out the pattern of growth of education and employment of women and the differential rate of growth of sectors over time. Data collection from secondary sources is in progress.

Demographic Study of Santals of Medinipur District of West Bengal

A pilot study on the project entitled Demographic Study of Santals of Medinipur District of West Bengal has been started in April 1997. The study will examine a variety of demographic processess that impinge on the size, structure and viability of the minority population. For the purpose of the major tribal group, Santal, which comprised 54 percent of total tribal Population and about 66 percent in Medinipur district in 1981 has been considered. To have further information village level data have been collected from the 1991 Census on the Medinipur district which are under process. This study is confined in the Jhargram block, which is Santal dominated. Five villages have been selected comprising Santal population as total, around 75 percent, 50 percent, 25 percent respectively. A set of questionnaires has been prepared and canvassed in the selected villages. The land records of these villages in the Block Land Reforms Office have also been searched to collect data on the main asset and land of the villagers. The collection of data from the records and the household survey has been completed.

Migration in India

Objective of this study is to highlight internal migration flow and Nepali migration in India. The Nepali migration has never assumed a status of large scale exodus at any point of time in the past. The work based on 1951-81 census data is complete. Nepali migrants show a declining trend. But during 1981-91 the volume of migrants have fallen significantly so that there has been a negative growth rate. The study has been completed.

Impact of Total Literacy Campaign in the District of Birbhum - An In-depth Study

A study on the Impact of Total Literacy Campaign in the districts of Birbhum and Bankura of West Bengal (sponsored by Govt. of W. B.) was undertaken in the year 1993. The report of the project was submitted to the govt. Now further attempts are being made to study the impact ofthe programme in terms of behavioural change and to develop method of quick assessment of the programme. Data entry has already been completed. Analysis of the data is in progress.

Mortality and Its Determinants in India

The purpose of this research is to analyse SRS data on mortality over the two decades following 1970. The study involves the national level as well as the regional level. Attempt is being made to study the mortality trends and determinants, and in particular those of infant, child and old age mortality.

Estimation of Volume of Illegal Migrants from Bangladesh

The independence of Bangladesh in 1971 created a vast displacement of population between Bangladesh and India, specially eastern region. Frequent crossing of borders continues to be a political flash point between Bangladesh and the eastern region of India. A large number of migrants from Bangladesh tend to hide their identity. An attempt has been made to estimate the volume of illegal migrants from Bangladesh to West Bengal using Census records. Population data by age and sex and place for all districts as well as for total West Bengal have been collected and compiled with the help of computer from 1961 to 1991 census records. Migrations datafor all districts and also for total West Bengal have been collected since 1971 to 1991. Derivation of methodology is under progress.

Publication of a Commemorative Volume of Professor Ajit Das Gupta's work in Demography

The primary objective of this proposal is to collate and compile the vast array of Ajit Das Gupta's (ADG) contributions to demography in a single volume. All his pioneering studies, being either not all documented or scattered in various journals, monographs and reports, are not easily available to the present generation of students and researchers. But for tracing the development of Indian demographic research, it is essential to have a thorough insight of ADG's scholarly and methodological work on population during the three decades (1950-70). The work is in progress.

Child Labour in India and its Determinants

This study examines the status of child labour (i.e., work participation of children aged 6-14 years) in India and its major states by various socio-economic and demographic characteristic from National Family Health Survey Data, 1991-93. Factors associated with the incidence of child labour is explored through multivariate statistical analysis.

Status of Obstetrics and Gynaecological Morbidity in Urban Areas in North 24-Parganas, W. B.

This study is focused on : (i) measuring different aspects of reproductive morbidity especially in the area of obstetrics and gynaecological morbidity, (ii) methodological issues in reproductive health measurement, and (iii) assessing non-contraceptive benefits of contraceptions on obstetrics and gynaecological morbidity among women aged 35 year and above. Field survey as well as data processing are going on simultaneously. Findings from this study may help the policy planners and providers of health and family planning care in assessing their needs.

Replacement Rates and Its Components in India

The objectives of this study are to : (i) develop a model which take into account all the major determinants of population growth from marriage through conception and live birth to the biological maturity of the second generation, (ii) examine the magnitude of the various components in the process, and (iii) use these components to estimate the replacement of couples in India by analysing National Family Health Survey Data (NFHS) : 1992-93.

This research is in progress.

Psychology Research Unit

Apart from research and project work, the faculty of this unit have been involved in the supervision of the theses of some Ph. D. students of Psychology and Education.

Research Activities / Projects Undertaken

A. Externally Funded Projects

Gender Study for the District Primary Education Programme

An in-depth gender study for the District Primary Education Programme has been undertaken in three

districts, namely, Birbhum, Murshidabad and Coochbehar of West Bengal. Special emphasis was given to look into the problems of girl students specially minority girls. Field work in all the three districts have been done Analysis and Report writing have been completed.

Mid-Term Review of Family Welfare (Urban Slums) Project IPP-VIII

In collaboration with the Population Studies Unit, ISI, a report has been completed and submitted to CMDA.

Concurrent Evaluation of Total Literacy Compaign in Uttar Dinajpur of West Bengal

The first and the second stage of concurrent evaluation of Total Literacy Campaign in Uttar Dinajpur district has been completed. The learning achievement of neo-literates was assessed and according to the NLM norms, the progress of the learners was found to be satisfactory. Report writing has been completed.

B. Plan Projects and Related Research

Potential Entrepreneur School Leavers

The objective of the study is to identify potential entrepreneurs from among the young boys and girls who can independently start some business or manufacturing units for their livelihood. A scale is being developed for small scale entrepreneurs by taking into account some essential psychological characteristics. Psychometric properties of the scale are being established for standardisation and future applications.

Motivation to Work for Primary Level Workers

For assessing the motivational level of primary level workers a questionnaire has been developed on the basis of study done on a group of 52 workers. 346 data from three groups of workers e.g., clerks, typists and factory workers have been collected. Simultaneously data collection has been started for vilidation of this test against ratings made by the supervisors.

Attainment Level of Primary Students at the End of Class IV in West Bengal

It is an ongoing project that aims to obtain a clear picture of the Non-scholastic achievements of the primary school pupils of West Bengal covering all the 18 districts of the State. Data have been collected from sampled schools of eight districts. Scoring, tabulation and computer data entry for evaluation have also been done. Analysis and writing of report is in progress.

Self-Efficacy, Intrinsic Motivation and Cognitive Functioning

The objective of the project is to study the role of self-efficacy and intrinsic motivation on cognitive functioning i.e., academic achievement of students. Literature review is going on. A preliminary study has been conducted in a nearby primary school.

Development of Computer Algorithm for Construction of Aptitude Test Battery for Computer Programmers

The task and responsibilities of the computer programmers are very complex and ambiguous in nature. This results in confusion in designing appropriate training, counselling and guidance programme for the programmers and also in determining their wage or salary structure. To these ends, a questionnaire has been developed to analyse the tasks of computer programmers and to identify the aptitudes required for performing the programming task. Data were collected from the programmers working in manufacturing organisations, financial and insurance services, professional, scientific and technical services, transportation sectors, information sectors, educational institute and administration through the job analysis questionnaire. Preliminary analysis based on a total of 100 programmers shows that five programming tasks, (i) comprehending users problem, (ii) testing and correcting programme, (iii) converting specification into detailed instruction, (iv) coding into computer language

and (v) modifying programme, took substantial part of their job assignment. The aptitudes namely, abstract reasoning, verbal reasoning, memorizing, numerical reasoning and language usage were noted as most important to perform the above five programming tasks. The findings would help in reducing ambiguity about the tasks and responsibilities of the computer programmers.

Study of Invariance of Item Parameters Across Social Groups of Likert Type Scales : an IRT Approach

For this project some software have been developed for analysis of data. Relevant parameters using Prolonged Deprivaion Scale have also been estimated. On the basis of these results obtained, a report is being prepared. Preparation of a Semantic Differential Scale is in progress.

Statistical Analysis of Influence of Personal, Social and Background Variables on Academic Achievement of Primary School Students (SURDAC Funded)

The objective of the study is to develop a probabilistic latent trait model to measure the ability of primary school children. A new model for analyzing performance data in arithmetic has been developed which extends the traditional Rasch model in a significant way. The non-response to items in a test has been given special importance in developing a vector valued assessment model, because a preliminary study revealed that such structured non-response may be useful in eliciting the self-confidence level of primary school children. The model has been tried out on the data collected from Murshidabad district during base-line survey of District Primary Education Programme. The study also intends to find out the relationship of latent trait with basic background variables such as gender, learner's generation index for education and other personal and social variables.

Statistical Modelling and Analysis of Psychological, Physiological and Ecological Repeated Measurement Data (SURDAC funded)

Objective of the project was to determine significant variation of state anxiety, physiological and ecological data across 12 months in Antarctic expedition. State anxiety and physiological data collected from 11 scientists and 7 logistic personnel across the months during Antarctic expedition. Hourwise ecological data were also collected. Result shows significant variation of state anxiety levels among the expeditioners across the months. Temperature, visibility, wind speed, station pressure and sea pressure significantly varied across different months. No significant variation was noted for wind direction across the months. In future, data would be analysed to determine significant variation of physiological changes and to determine relationship among psychological, physiological and ecological parameters.

Sociological Research Unit

The faculty members of the Unit participated in teaching Sociology for B. Stat. students. Guidance was also provided to Ph. D. Scholars in Anthropology at Calcutta University.

Research Activities / Projects Undertaken

Involvement of People in the Decentralized Planning Process : Experience in West Bengal

The study has already been initiated in Midnapore and Purulia districts by examining various Gram-Panchayat and Panchayat Samity level plans and reports and through identification of appropriate respondents at village, block and district levels.

Transfer of Ownership of Properties and Changing Social Scenario in the City of Calcutta - a Sociological Analysis

Due to the increasing trends of population density of Calcutta, demand for housing has become, during the last few decades, extremely acute. This has opened up land market to the promoter-contractor nexus. Earlier this process of transfer of property was a somewhat gradual change which has now become abrupt and conflict-ridden. Under this purview, the proposed study is to enquire the following : (i) to identify the socio-linguistic groups in

different parts of Calcutta metropolis which are involved in the phenomenon of transfer of ownership of land and residential housing, (ii to make an outline of the socio-cultural, economic and other related factors of those who have been or are being uprooted from the original settlements, and (iii) to examine whether a process of alienation has started as a consequence of this social situation.

Changing Adaptive Strategies of a Rehabilitated Population - a Social-Ecological Approach

Nearly 600 families were rehabilitated at Barasat in North 24 Parganas in between 1965 and 1968. These families originally migrated from Chittagong (now in Bangladesh) to areas belonging to Burma (Mayanamer) during the year 1939 in search of better occupation. In 1964, the Govt. of Burma decided to evict the non-Burma residents from their country. As a result, the group of Chittagong people along with other Indians left Burma as they were brought by the Government of India. The said displacement brought them in a completely different ecological frame which was not so familiar to them. Considering both the external and internal conditions that existed in that area they had to formulate plans of action for their social and economic survival, which may be termed as adaptive strategies.

The proposed study is to aim at enquiring the following : (i) to identify the ecological (both social and natural) areas from where they were displaced along with their present habitation, (ii) to explore their adaptive strategies with their respective application, (iii) to make an outline of the socio-cultural, economic and other factors to assess their role in formulating adaptive strategies and (iv) to examine whether a process of alienation has started as a consequence of this social ecological situation.

Forest Protection and Income Generation for the Tribal Poor - Evaluation of an Organised Movement

The process of data analysis has been completed and final report writing is going on.

Scope and Constraints of Rural Women Leadership with Special Reference to Experimentations in Local Self- Government bodies.

An interim report has already been completed. Final report is being prepared.

Interpersonal Contacts and Social Development : a Rural Experience in West Bengal

The process of data collection and analysis has been completed. Final report is being prepared.

Statistical Quality Control and Operations Research Division

The basic objective of the Division is to propagate the use of quantitative methods of SQC & OR and other allied management techiniques for reducing losses and cost of manufacturing, improving quality of product and services and augmenting productivity in Indian industry. This is realised through academic programmes, consultancy services, inplant and general training courses for personnel from industry and service organisations, and research in the methods and procedures of quality control, quality reliability and allied techniques. Recognizing the pioneering role and rich contribution of the Division in the quality movement in the country the Government of India has nominated the Institute as a permanent member of the ***Quality Council of India***.

The Division is running a two year M. Tech course to turn out professionally competent specialists for industry. The Division also offers a Specialist Development Programme (SDP) to provide career in industry through on the job training and guided development. Presently 7 SDP Fellows are being trained in the Division. Besides, Part time evening courses in Statistical Quality Control and Operations Research are run at Bangalore, Hyderabad and Chennai centres. Besides, the Division participates in teaching for B. Stat., M. Stat. programmes of the Institute, training programmes conducted by ISEC and part time evening course in Statistical Methods at Delhi and Calcutta. The Division also assists other Institutes and Universities for conducting their academic programmes.

Consultancy Services

The Division has been providing consultancy services in all areas of Quality Management and productivity. At present 126 organizations are taking services of the Division. The SQC & OR Units of the Division are also vigorously pursuing Quality System Work related to ISO 9000 certification and providing consultations in this area. The Division has also conducted QS 9000 surveillance Audit for 3 organisations one each from Malayasia, Philippines and Thailand. The Division has embarked on promoting SQC & OR in SAARC and other neighbouring countries and a Cell for Export of Consultancy Services has been formed in Calcutta. The Cell has brought out a specially designed brochure for this purpose. The Cell has already taken up an assignment in Oman.

Quality Improvement Projects Highlights

(a) Optimum Launching Quality in PCB Manufacturing : A method was developed to determine the number of excess PCBs over the order quantity to be launched to account for the possible rejections while manufacturing, by minimizing the total cost due to shortages and overages. Evaluation over a six month period showd that the implementation of this method had helped in reducing the shortfalls from 15 % to 10% while keeping the excess production at the same level.

(b) Intergrating SPC with EPC - A case study : The Rayon grade pulp viscosity is mainly controlled at the Hypochlorite bleaching stage. A regression model was developed relating the output viscosity with the input viscosity and hypo solution dosage at the Hypo bleaching stage. The errors in the regression model are found to be correlated over time and hence a time series model (ARMA) on the errors was fitted. The hypo dosage for any particular time is predicted from this 2- stage model using Minimum Mean Square Error (MMSE) criterion. The results of implementation in the plant are under monitoring. It is expected that the nonconformance of viscosity will come down to about 20 % from the current level of 30 %

(c) Using experimental methods a process was developed for 100% cotton fashion yarn through fiber dyeing instead of fabric dyeing. The process so developed received international recognition. About 700 tons of this fashion yarn working about 3.5 million US dollar was exported from India subsequently. This yarn maintained environmental standard without sacrificing quality but with high value addition.

(d) Production of Furescent Tube Light (FTL) shells is a continuous process. FTL Shells are produced by simultaneous blowing of air through molten soda glass and drawing the blown up glass. Rejection due to bad glass (glass with bubbles) was of major concern. At times the rejection level due to bad glass was found to be as high as 50% of the total production in a shift. Analysis of shiftwise rejection data revealed that the process was highly unstable. Presence of both sporadic as well as sustained shifts in rejection level was found to be a normal feature of the process. Further analysis of past data revealed that optimum selection of the process parameters might reduce the level of rejection greatly. The approach adopted for optimization of the process parameters is robustification of the basic functiion of the process. The basic function was identified to be $\pi L \rho (D-t) t = W$ where W is the weight of the input materials (as measured by the weight of the tubes) and ρ, L,D,t are the density of glass, length, outside diameter and thickness of the tube respectively. The four control factors identified for optimiziation are furnace temperature, rear temperature, muffle temperature and blowing air pressure. The best combination of the control factors were then validated using past data and was found to lower the rejection level significantly by about 10%.

(e) More than 10% of injection moulded plastic electrical connectors were being rejected owing to shrinkage defects problems. It was decided to conduct a planned experiment using orthogonal array to optimize the machine parameters. Five control factors, each having three levels, where assigned to the Orthogonal Array (OA) L_{18} to obtain the design matrix. The control factors chosen are (i) injection pressure (ii) injection time (iii) first zone temperature of the heater (iv) last zone temperature of the heater and (v) cooling time. The died dimensions, i.e. thickness, width height, width and length were taken as four levels of the signal factor. At each trial of the design matrix nine connectors were produced under nine different noise conditions (Cavity no. x time of production) and four dimentions of the connector corresponding to the different levels of the signal factors were measured. Both Signal-to-Noise ratio and the intercept of the basic function i.e. the observed dimension as a function of signal dimension for each trial were computed and analysed using the techniques of ANOVA to arrive at the optimum

combination of the control factors. Confirmatory trials with the optimum levels of the five factors gave highly satisfactory result. The recommended levels were implemented and not a single case of rejection due to shrinkage was observed during the next three months.

Quality Mission Project (QMP)

Quality Mission Executives (QME) under QMP continued their active participation in conducting training programmes and rendering Quality Systems related consultancy services to industries and service organisations. During the year, the QMEs have rendered 241 day's service in consultancy, 30 days in training programmes and have trained 483 persons at various levels in Industries and service organizations. In addition, they paid promotional visits to a large number of organizations and were actively engaged with consultancy on ISO systems. The Kinetic Engineering company received ISO 9000 Systems certification for which guidance was provided by a QME. QME's now undergo training to include modified QS 9000 Quality Management Systems and the associated requirements such as Advance Quality planning, Failure Mode and Effect Analysis, Measurement Systems Analyses. A special three day training was conducted by experts from Indian Society for training and development on how to conduct training programmes for the QMEs. During the current year QMEs successfully completed Lead Assessors Certificate Programme conducted by accredited agencies. The SQC & OR Unit, Chennai organised a seminar on Quality Management for Leather Industry as a part of its QMP acitivities.

Training Courses

About 159 Tailor made in house programmes to suit the specific requirements of different organizations and about 45 short duration courses on specific topics were conducted. These programmes covered a wide spectrum of areas of control and breakthrough like Statistical Process Control, Industrial Experimentation and Taguchi Methods, TQM, ISO 9000, QS 9000, Internal Quality Audit FMEA, QFD, Six sigma process and Reliability. A large number of appreciation and motivational courses were conducted for workers in regional languages. Special programmes were conducted for Institute of Wood Science and Technology, TVS Suzuki, BEML and Bureau of Economics and Statistics.

The extent of consultancy, inplant and general training programmes are summarised below :

(i) Number of Industrial units serviced	126
(ii) General Programmes	
Number of programmes	45
Number of participants	519
(iii) Inplant programmes	
Number of programmes	159
Number participants	4722
(iv) Seminar talk	
Number of programmes	48
(v) Number of promotional visits	118

A brief details of Inplant and General Training Programmes organised by the Division for Engineers, Top Executives, Junior Executives, Senior and Junior Management Staff, R&D Personnel, Supervisors, Operators etc. are indicated below :

Inplant Training Programmes

Sl. No.	Title of the Programme	Duration	Name of the Organisation	No. of Participants
1	QS 9000 awareness	April 1998	Stumpp, Scheule & Somappa	20
2	Quality Systems in Measurement	April 1998	J K Tyres	21
3	Measurement System Analysis, control plan	April 1998	ABB	21
4	Team Oriented Problem Solving	April 1998	Autoliv	10
5	KAIZEN	April 1998	Autoliv	10
6	QS 9000 (1998)	April 1998	IFB	12
7	TPM	April 1998	IFB	15
8	Middle management training programme	April 1998	Royal Enfield Motors	15
9	Statistical Process Control	April 1998	Central Electronics Ltd., Ghaziabad	25
10	Design of Experiment	May 1998	Modi Xerox, Rampur	15
11	Quality Engineering	May 1998	Glowtronics, Mysore	12
12	ISO awareness	May 1998	Motorola	12
13	Vendor Quality Assurance	May 1998	IFB	50
14	Quality Cost	May 1998	IFB Autoliv	8
15	Calibration Quality System and Estimation of Measurement Uncertainty	May 1998	Indian Aluminium Co. Ltd.	15
16 16	Top management training Programme on SPC	May 1998	I.T.C. Limited	6
17	Quality Awareness	May 1998	M/S Sangeeth Textiles Ltd.	700
18	Statistical Process Control	May 1998	Eicher Motors Ltd.,Pithanpur (MP)	25
19	Quality Cost	June 1998	NGEF	20
20	ISO 14000	June 1998	Grasim, Harihar	30
21	Six Sigma	June 1998	Thermax, Pune	12
22	Awareness Programme on QS 9000	June 1998	IFB	35
23	Awareness Programme on QS 9000	June 1998	IFB	30
24	Intensive course on QS 9000 for operators	June 1998	IFB	30

INDIAN STATISTICAL INSTITUTE
SCHEDULE II

SCHEDULE OF INVESTMENT AND INTEREST ACCRUED AS ON 31ST MARCH 1999

PARTICULARS	INVESTMENT		ACCRUED INTEREST		TOTAL
	RS. P.	RS. P.	RS. P.	RS. P.	RS. P.
1 FIXED DEPOSIT WITH :					
1 UNITED BANK OF INDIA	2,820,000.00		55,838.00		
2 ALLAHABAD BANK	600,000.00		23,850.00		
	3,420,000.00		79,688.00		3,499,688.00

S.Sengupta
Accounts Officer

S. S Panja
Accounts Officer

Anup Majumdar
In-Charge
Administration &Finance

S. B. Rao
Director

For Sarma & Co.
Chartered Accountants

8/2 Kiran Sankar Roy Road
Calcutta-700001
13 October 1999

B Sinha
Partner

INDIAN STATISTICAL INSTITUTE
SCHEDULE III
LOANS AND ADVANCES AS AT 31ST MARCH 1999

Previous Year	Particulars	Current Year
30,848.34	Advances for land	30,848.34
231,976.71	Security deposit paid	288,576.71
81,350.80	Sundry Debtors Party in recoverable	81,350.80
9,934,231.63	Charges prepaid	13,497,664.00
19,429,300.00	Marginal Deposit	13,279,100.00
350.00	Students Benefit Fund	350.00
3,171.71	CTD (Giridih & Delhi)	3,171.71
892.00	Educational Loan	892.00
42.00	House Building loan(Old)	42.00
46,283.64	Relief (Flood & draught)	45,447.64
796,527.40	Advance against T.A.	568,671.33
1,116,397.22	Advance Against LTC	1,200,918.22
4,429.96	Fan advance	4,429.96
772,811.36	Advance against purchase of Cycle & Scooter	198,723.96
1,486,668.64	Suspense & Advance(Staff & Other)	4,327,460.68
6,218,104.91	Suspense and Advance (Party)	5,311,386.95
920,763.50	Festival Advance to staff	1,269,930.50
42,000.00	Departmental Imprest	80,000.00
6,171.90	Group Insurance(Br.Except.Delhi&Giridih)	85,514.90
221,008.27	ISI UEA Collaborative Project	22,541.36
-	Environment Management Capacity	2,336.60
4,450.00	CTD ISI PPU	38,980.00
9,250.00	Staff Insurance Premium(PPU)	-
29,592.00	ISEC(UNDP) STAT-OPERATION	-
-	Advance against purchase of Scooter	278,977.00
-	Staff Insurance (Delhi & Giridih)	3,248.06
41,387,111.99		40,620,562.72

S Sengupta
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13 October 1999

B Sinha
Partner

INDIAN STATISTICAL INSTITUTE

SCHEDULE IV

LIABILITIES AND ASSETS OF OTHER FUNDS AS ON 31ST MARCH 1999

LIABILITIES RS. P.	ANNEXURE	NAME OF FUND	ANNEXURE	ASSETS RS. P.
58,596,822.17	A	1. STATISTICAL QUALITY CONTROL DEV. FUND	A	58,596,822.17
3,864,249.50	B	2. DEVELOPMENT FUND	B	3,864,249.50
80,238.03	C	3. MAHALANOBIS INTERNATIONAL SYMPOSIUM ON STATISTICS PRIZE FUND	C	80,238.03
66,174.79	D	4. DANIEL THORNER MEMORIAL FUND	D	66,174.79
31,361.24	E	5. ENDOWMENT FUND FOR LECTURE IN ECONOMIC	E	31,361.24
40,901.31	F	6. INDIAN STATISTICAL INSTITUTE ALUMNI ASSOCIATION PRIZE FUND	F	40,901.31
109,669.27	G	7. HALDANE PRIZE FUND	G	109,669.27
808,938.48	H	8. PROF. P.C.MAHALANOBIS CHAIR/ FELLOWSHIP FUND	H	808,938.48
93,778.50	I	9. RAJA RAO MEMORIAL FUND	I	93,778.50
130,166.00	J	10. M. N. MURTHI MEMORIAL FUND	J	130,166.00
29,976,455.87	K	11. PROJECT SETTING UP A PLAN AND POLICY RESEARCH UNIT AT THE ISI NEW DELHI	K	29,976,455.87
267,875.00	L	12. AMBARNATH-SHANTI GHOSH ENDOWMENT FUND	L	267,875.00
687,897.26	M	13. DIRECTOR'S CONTRIBUTION FUND	M	687,897.26
92,754,527.42				92,754,527.42

S Sengupta
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B Sinha
Partner

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13 October 1999

INDIAN STATISTICAL INSTITUTE

ANNEXURE A

(ANNEXURE A, FORMING PART OF SCHEDULE IV OF THE ACCOUNTS OF THE INSTITUTE)
"STATISTICAL QUALITY CONTROL DEVELOPMENT FUND" A/C NO. 680-888
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 1999

PREVIOUS YEAR RS P.	EXPENDITURE	CURRENT YEAR RS. P.	PREVIOUS YEAR RS. P.	INCOME	CURRENT YEAR RS P
563,608.86	TO COMPUTER CONSUMABLES & REVENUE EXPENDITURE	736,826.00	2,266,833.50	BY INTEREST ON INVESTMENT	2,252,878.50
1,713,224.64	EXCESS OF INCOME OVER EXPENDITURE	1,516,052.50			
2,266,833.50		2,252,878.50	2,266,833.50		2,252,878.50

BALANCE SHEET AS AT 31ST MARCH 1999

PREVIOUS YEAR RS. P	LIABILITIES	CURRENT YEAR RS. P.	PREVIOUS YEAR RS. P.	ASSETS	CURRENT YEAR RS P
44,774,920.86	FUND : AS PER LAST ACCOUNT	50,633,772.47	19,702,677.81	1. FIXED ASSET	21,088,425.24
			18,147,000.00	2. INVESTMENT IN FIXED DEPOSIT	26,147,000.00
1,713,224.64	ADD : EXCESS OF INCOME OVER EXPENDITURE	1,516,052.50		3. CURRENT ASSETS :	
			424,314.00	.1 INTEREST ACCRUED BUT NOT DUE ON FIXED DEPOSIT	533,847.50
4,145,626.97	ADD : EXCESS OF SQC RECEIPTS OVER RS.7,00,000.00 TRANSFERRED FROM CURRENT EXPENDITURE ACCOUNT	4,448,997.20	12,359,780.68	.2 BANK BALANCE FORMING PART OF INSTITUTE'S CASH & BANK BALANCE WITH SCHEDULE VI	8,849,749.43
50,633,772.47		56,598,822.17	50,633,772.47		56,598,822.17

S Sengupta
Accounts Officer

S S Panja
Accounts Officer

Anup Majumdar
In-Cargo
Administration & Finance

S B Rao
Director

In terms of our separate report of even date

For Sarma & Co.
Chartered Accountants

8/2 Kiran Sankar Roy Road
Calcutta-700001.
13 October 1999

B Sinha
Partner

INDIAN STATISTICAL INSTITUTE
ANNEXURE B

(ANNEXURE B, FORMING PART OF SCHEDULE IV OF THE ACCOUNTS OF THE INSTITUTE)
"DEVELOPMENT FUND" A/C NO. 660-669
"INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 1999

PREVIOUS YEAR RS. P.	EXPENDITURE	CURRENT YEAR RS. P.	PREVIOUS YEAR RS. P.	INCOME	CURRENT YEAR RS. P.
260,464.00	TO EXCESS OF INCOME OVER EXPENDITURE	230,224.00	260,464.00	BY INTEREST ON INVESTMENT	230,224.00
260,464.00		230,224.00	260,464.00		230,224.00

BALANCE SHEET AS AT 31ST MARCH 1999

PREVIOUS YEAR RS. P.	LIABILITIES	CURRENT YEAR RS. P.	PREVIOUS YEAR RS. P.	ASSETS	CURRENT YEAR RS. P.
2,416,384.32	FUND : AS PER LAST ACCOUN	2,990,003.60		1. FIXED ASSET	
				2. INVESTMENT IN FIXED	
	ADD : EXCESS OF INCOME		2,012,000.00	DEPOSIT	2,012,000.00
260,464.00	OVER EXPENDITURE	230,224.00			
				3. CURRENT ASSETS :	
				.1 INTEREST ACCRUED BUT	
			40,428.00	NOT DUE ON FIXED DEPOSIT	29,177.00
	ADD: DURING THE YEAR				
	SHARE OF OVERHEAD CHARGES FROM EXTERNALLY			.2 BANK BALANCE FORMING PART OF INSTITUTE'S CASH & BANK BALANCE WITH	
323,165.18	FUNDED PROJECT	644,022.00			
			937,675.60	SCHEDULE VI	1,823,072.60
2,990,003.60		3,864,249.60	2,990,003.60		3,864,249.60

S Sengupta Accounts Officer	S S Panja Accounts Officer	Anup Majumdar In-Charge Administration & Finance	S B Rao Director

92 Kiran Sankar Roy Road
Calcutta - 700001
13 October 1999

In terms of our separate report of even date

For Sarma & Co.
Chartered Accountants

B Sinha
Partner